JOURNAL

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2

TELEPHONE: TEMPLE BAR 7676 TELEGRAMS: VOLTAMPERE PHONE LONDON

VOLUME 1 (NEW SERIES) NUMBER 5 MAY 1955

PUBLISHED MONTHLY PRICE FIVE SHILLINGS

ANNUAL SUBSCRIPTION TWENTY-FIVE SHILLINGS

Contents

PAGE	
277	LIFE-BLOOD
278	AUTOMATIC CONTROL *by* J. F. COALES, O.B.E., M.A.
280	THE HISTORY OF ELECTRICAL ENGINEERING—3 *by* C. MACKECHNIE JARVIS
287	THE HONORARY SECRETARIES' CONFERENCE
288	THE ANNUAL DINNER
297	THE MEASUREMENTS SECTION DISCUSS ELECTRONIC INSTRUMENTS
299	DIGESTS OF PAPERS IN THE *PROCEEDINGS*
308	HOME EVENTS
314	NEWS FROM ABROAD
316	OBITUARY
318	CORRESPONDENCE
319	TECHNICAL PUBLICATIONS
323	LIBRARY ACCESSIONS
328	MONOGRAPHS AND PAPERS PUBLISHED SEPARATELY THIS MONTH
330	SOME RECENT BOOKS
332	ANNOUNCEMENTS TO MEMBERS
334	THE *JOURNAL* REFERENCE SECTION

The Institution is not, as a body, responsible for the opinions expressed in the *Journal*, unless it is stated that an article or a letter officially represents the Council's views.

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 1 (NEW SERIES) NUMBER 5
MAY 1955

LIFE-BLOOD

ELECTRICAL ENGINEERING IS FOUNDED ON RESEARCH and lives by research. In the earliest days great scientists and adventurous practical men directly applied the discoveries of their time. With the greater specialization there appeared, on the academic side, university departments of electrical engineering, which have directed their research both to short-term applications of scientific principles and to subjects which might reveal more distant applications. Technical colleges play a part which could be much greater with better facilities and more relief from teaching duties. Post-graduate student research has to compete with the claims of practical training. No one desires a situation, as in physics, where nearly all the best graduates are withdrawn from professional life for two or three years to take a higher degree; but academic electrical engineering research deserves the encouragement of an appropriate allowance in reckoning the period of practical training required for Associate Membership of The Institution.

In Great Britain the majority of electrical engineering research is carried out by industry in research departments, separate establishments, or autonomous bodies for research and development which serve industrial groups. The supply industry, which now has a statutory duty in research, disposes of great resources for large-scale trials and field studies in power supply and distribution, with laboratory research services for their nourishment. The electrical industry as a whole devotes as much effort to research in proportion to its size as does its counterpart in the United States, often quoted as an example. Large research establishments are naturally the province of the largest organizations, but the work of individual engineers in small firms must not be overlooked, even though such engineers do not call themselves research directors.

The Government's greatest expenditure is on defence, which, nevertheless, influences, in a special way and to an extent not always appreciated, industrial research through contracts that call for it. But other national responsibilities need electrical research. The Post Office, indeed, now largely supplies a central research service to the communication industry. With the Radio Research Board it deals with every kind of communication problem. The electrical sides of the National Physical Laboratory and other D.S.I.R. stations are considerable. The N.P.L. is the custodian of standards embodying the highest precision reached by measurement.

Research associations form the main joint enterprise of Government and industry. The Electrical Research Association, one of the largest, has resources which are small compared with those of the industry and might well be expanded; but by pursuing basic research into common problems, into aspects of sciences on which electrical engineering is based and into speculative projects, it influences a much greater volume of work by industry. Its largest support comes from the supply industry, and this emphasizes research into questions affecting the user, but it also serves small firms which cannot afford research departments. The electrical industry contributes to some 20 other research associations. This illustrates the tradition that electrical engineering gives all possible help to the technologies which supply its materials and components or which use its products. Great user industries, like transport, have always been strong in their employment of electrical engineering; most technologies are now affected.

Electrical engineering research continually draws on the discoveries of physics, chemistry and other sciences. It gives back much to fundamental science, in addition to its engineering services. Electrical research laboratories have made famous discoveries because they have the men, the means and the encouragement to pursue original ideas. Scientific discoveries are applied so rapidly that much of the research is at first incomplete. In physics many lines of investigation have been abandoned by academic physicists and later pursued in electrical engineering research laboratories. Electrical research more than repays its debts.

The mosaic of research effort forms, by its voluntary integration, an imposing picture which fits into the broader panorama of The Institution itself. The Institution is the prime means of disseminating, discussing and assessing the results of electrical research. It has intervened directly when necessary; among many examples, two notable actions were its joint foundation of the Electrical Research Association and its sponsoring of the

Chair of Electrical Engineering at Cambridge University. Nevertheless, the profession faces grave problems. The shortage of suitable entrants limits its activities, including research. Student apprenticeship in a research establishment is capable, for example as a component of a sandwich course, of playing a useful part in the training of an electrical engineer. Contributions to electrical research come from graduates in subjects other than electrical engineering and their association with the profession has not perhaps been fully determined. It is doubtful whether electrical engineering faculties obtain a fair share of those with a scientific bent who will make the best research engineers. Possibly the term "electrical engineering research" hardly conveys the full extent of the activities of electrical engineering research laboratories. Though conditioned by the hope of successful application, they are pursued in the spirit of free and broad enquiry. The foundations of electrical engineering research are recent but it is ever ready to renew them from other disciplines or from its own studies. It can offer the satisfaction of concrete achievement and the thrill of the discovery of new knowledge.

AUTOMATIC CONTROL

Much of this short article originally appeared in the "Cambridge Review," and we are grateful to the Editor of that journal for permission to reproduce it here.

J. F. COALES, O.B.E., M.A., *Member*

EVER since the enormous advances made in automatic control during the war, the subject has increased in importance. Automatic controls, essential for guided weapons and other engines of war, have become equally essential for safety in many civil activities, such as those of high-speed flight and atomic energy. To-day, not only are the majority of chemical and oil-refining processes automatically controlled but each year sees more and more industrial processes, from colour-printing to steel-making, being made automatic, either to attain improved quality or to reduce the cost of labour.

The developments of the past years have resulted not solely in the automatic control of manufacturing plant but also in the development of automatic office equipment, which can do most of the paper work of a factory without the aid of clerks. Computers are now in operation, which, besides carrying out the multitude of calculations required by bonus schemes and P.A.Y.E., are solving problems quite as complicated as those which arise in the planning departments of most works. Thus the tools exist, which, together with mechanical handling gear, could form the completely automatic factory, in which the Board, having decided the policy, feeds into a computing machine a series of instructions and criteria, and then leaves it to the computer to send out the instructions to the factory in the light of orders received.

Owing to the present shortage of labour, there is an immediate demand for each of these automatic departments, but no attempt has yet been made to link them together into a complete unit. The reason for this is twofold. First, owing to the limit on the rate at which capital equipment can be built, it is possible to re-equip industry only very slowly, and no firm could normally afford to have a fully employed works out of action for sufficient time to make the change-over. Secondly, a completely automatic factory implies at the present time a large amount of complicated equipment, the reliability of which is suspect; therefore the risk of frequent shut-down, due to faults in the control, is a major deterrent. Thus automatic control is being applied to industry only piecemeal. There is not much doubt that the greatest savings in cost of production can be achieved only when all these labour-saving devices are integrated, but there will be little advantage if, when this is done, the more-or-less unskilled operators who at present tend machines have to be replaced by highly-skilled maintenance technicians. There is no fundamental reason why automatic control equipment, even though it employs a great many components, should not be made very reliable and easily maintained, but it is obvious that, no matter how well components are designed, the greater their number, the greater will be the chance of the equipment's failure and the time spent on its maintenance and repair. It is, therefore, this question of reliability which is the most urgent present consideration of control engineers. Further, since existing manufacturing techniques have been developed for human control and operation, it is evident that, in order to arrive at simpler and more reliable systems, different manufacturing methods must often be developed.

In the past, the components, instruments, amplifiers, motors, etc., that go to make up automatic control systems have been designed so that they are linear over the range in which they operate, because this makes the analysis of such systems possible, and, therefore, eases the design of new systems to meet known requirements. This insistence on operation in the linear range only has resulted in unnecessarily generous designs, which have been costly and inefficient. Recently, it has been realized that automatic control systems could, almost certainly, be very much simpler, cheaper and more reliable if non-linear components were used, in which the output of each component is not directly proportional to the input. Unfortunately, the introduction of any non-linear component into a control system (and the manufacturing process itself is more often than not non-linear), greatly complicates the governing differential

equation of the system; although the physical system may be simpler the theory often becomes quite intractable. As a result, no general methods of analysis of such systems are known, and so, in most cases, there is little guide to the best system to meet a given requirement. The design of non-linear automatic control is in its infancy, but much work has already been done on the theoretical aspects in Russia, and on the more practical side in the United States. Some work has been carried out in Britain, but mostly by isolated workers. For the past two-and-a-half years a small group has been working in the Cambridge University Engineering Department on both the theoretical and practical aspects of non-linear control; a seminar on Non-linear Control Problems was organized last September, and this drew to Cambridge many of the leading people working on this subject in Britain. The recorded proceedings of the seminar are only being distributed privately, but the main papers are appearing in the *Proceedings* and other publications.

Recent developments in the study of automatic control have had the effect—which may seem strange to some—of bringing together engineers and economists, for certain analogies can be drawn between economic systems and the more complicated engineering projects. For many years now economists have realized that the laws of cause and effect in economics result in closed-loop systems in which there are clearly defined feedback paths. Thus in an economic system the total amount of money available is directly linked to what is spent on consumer goods and capital expenditure. Furthermore, what is produced must equal what is consumed plus any increase in stocks. How stocks affect production and hence percentage employment and spending power is clearly dependent on the delays involved, but flow diagrams can be drawn and the delays can be represented by the use of differential equations as in control problems. The main difference is that economic systems cannot be represented except by a large number of interconnected loops, whereas most control systems involve only two or three subsidiary loops. Moreover, up to the present most economists have considered only fixed delays, but engineers have usually worked with exponential delays, which lead direct to differential equations. Last September, a joint meeting of economists and engineers was held under the chairmanship of Professor R. F. Kahn, of the Faculty of Economics, Cambridge University, to discuss the analysis of economic systems. The discussion was opened by Professor A. Tustin, Professor of Electrical Engineering at Birmingham University (author of "The Mechanism of Economic Systems"*), who suggested how the methods applied by engineers might be used to analyse, and possibly modify, economic systems. In the discussion that followed, members of the Faculty of Economics (as well as members of the seminar) took part. Professor Kahn, in winding up the discussion, stressed the importance of collaboration between economists and engineers in investigating models of economic systems. He felt, however, that he personally could have faith in these models only qualitatively, and he doubted whether it would ever be wise to act on the quantitative results.

Professor Kahn's view was founded on the vast complication of an economic system and the uncertain nature of the input data, facts with which no engineer will disagree. The optimistic engineer, however, cannot but recall the very complicated systems of gunnery prediction which were made to work, despite complicated interactions and wildly fluctuating inputs of unknown statistical form, at a time when little was understood about feedback systems. In some of these the number of interacting processes and input quantities were very large. The past 10 years have seen the development for defence purposes of systems far more complicated, the behaviour of which can be investigated only by the use of enormous computing machines, and the unknown quantities in such systems must be comparable in number with those of any economic system.

* Heinemann, 1953.

Journal I.E.E., May 1955

The History of Electrical Engineering

3. MACHINERY FOR THE NEW LIGHT: PART I

In this article the author describes the development of the magneto-electric machine and its application to lighthouses. It is interesting to realize what a large part safety at sea has played in evolving the design of modern electric generators. The next article in the series will be concerned with the progress of the dynamo-electric machine.

C. MACKECHNIE JARVIS, *Member*

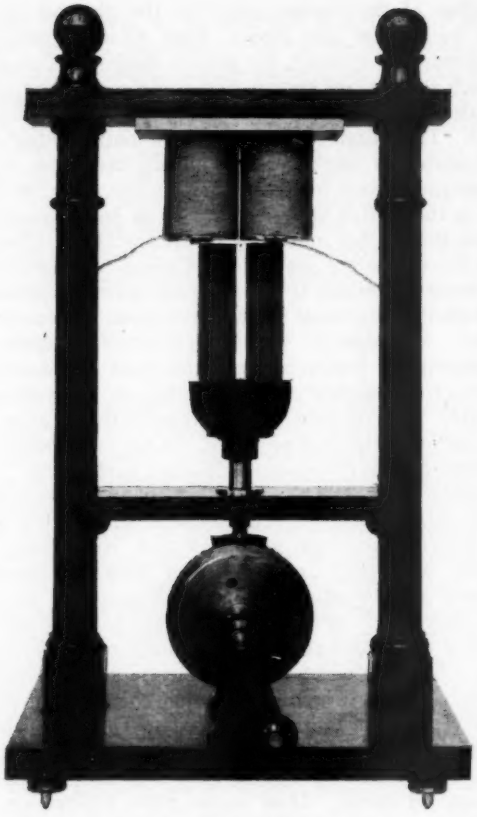
IT has frequently been observed that Faraday took surprisingly little part in the development of electrical machinery and had absolutely no desire to profit financially from his discoveries. It must, of course, be remembered that he was directing research at the laboratories of the Royal Institution in several fields, and that at the time chemistry probably interested him more than electricity and magnetism.

There were many lesser lights who speculated on each new fundamental discovery announced from the laboratories of such men as Faraday, Ampère and Arago, as well as men of vision who perhaps perceived more in the potentialities of the new force than those intimately concerned with it. Some idea of the enthusiasm exhibited at this time may be gauged from the following advertisement which appeared in the *Dundee Advertiser** on the 11th April, 1834:

J. B. Lindsay resumes classes for cultivating the intellectual and historical portions of knowledge and instruction on 14th April 1834 in South Tay Street, Dundee. In a few weeks hence a course of lectures will be formed on frictional, galvanic and voltaic electricity, magnetism and electro-magnetism. The battery, already powerful, is undergoing daily augmentation. The light obtained from it is intensely bright and the number of lights may be increased without limit. A great number of wheels may be turned and small weights raised over pulleys. Houses and towns will in a short time be lighted by electricity instead of gas, and heated by it instead of coal, and machinery will be worked by it instead of steam—all at trifling expense.

Most engineers would agree that apart from the last phrase(!) the prophecy has been fulfilled.

Meanwhile, in 1832, M. Hyppolyte Pixii exhibited before the Paris Académie des Sciences a hand-driven magneto-electric generator in which a U-shaped permanent magnet was caused to rotate below a soft-iron core of somewhat similar shape that was fixed to a stationary frame. Two coils joined in series, one on each leg of the fixed core, were swept with the field of the magnet during rotation, and in them was thus generated a somewhat discontinuous alternating current. A simple commutator enabled the alternate pulses to be reversed so that the current delivered to the external circuit, although pulsating, was unidirectional.



1 *Replica of Pixii hand-driven magneto-electric generator (about 1832)*

Crown copyright. From an exhibit in the Science Museum, South Kensington.

The machine of Pixii was the prototype of many magneto-electric machines which followed. It will not be possible in this series of articles to refer to them all, but a selection of the many designs produced by different constructors during the evolution of an effective heavy-current generator will be reviewed.

Following Pixii's ideas, Saxton exhibited at the Cambridge meeting of the British Association in 1833 an improved hand-driven machine, in which the permanent magnet was made stationary and the coils caused to rotate, this generator possessing the relative advantage of reduced weight of the rotating parts. A machine of this type was one of the items claimed in an omnibus telegraph patent granted to C. Wheatstone and W. F. Cooke

* Quoted in the *Transactions of the Newcomen Society*, 1934, 14, p. 106.

in 1840, and one was again patented in 1842 by J. S. Woolrich in connection with electroplating.

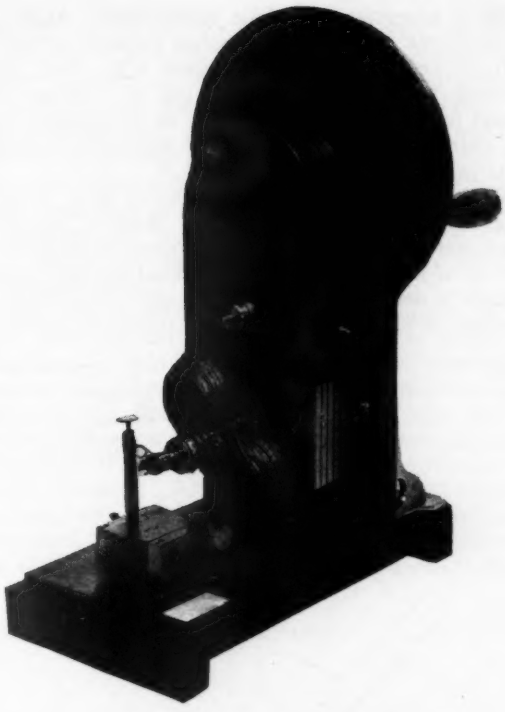
To E. M. Clarke, an instrument maker of London, is due the first commercial application of a magneto-electric generator. Clarke's machine of 1834 differed from its predecessors in that the coils were caused to rotate in a plane parallel with the side of the magnet. The machines were used in laboratories and became popular in Victorian households in consequence of their claim to have beneficial results in alleviating rheumatism and several other disorders. The degree of electric shock sustained by the subject could be controlled by the rate at which the handle was turned and by a magnetic shunt, or strip of steel, arranged to move across the poles of the magnet.

Hand generators of the Clarke type continued to be made and sold as electric "batteries" at least until the end of the century. According to contemporary accounts, Clarke varied the windings on his twin-coil rotors and demonstrated that by using wire of relatively heavy section he could produce a brilliant arc with little shock, and by using many turns of fine wire, slight sparks but powerful shocks. Although the earlier machines embodied a commutator, this was omitted from the more popular models sold for therapeutic purposes. Clarke's machines were not patented.

The machine devised by Stöhrer of Leipzig in 1843–44 was a hand-operated generator in which a group of six coils on a revolving disc moved across the extremities of three U-shaped magnets. This machine, which was fitted with a commutator, embodied features of the earlier machines of Pixii and Saxton, but was of an improved and more robust construction. It is principally of importance in that it constituted the arrangement first adopted by Floris Nollet (1794–1853), who was Professor of Physics in Brussels at the time, in his attempt in 1849 to produce a large-scale power-driven magneto-electric generator.

Nollet was interested in lighthouse illumination and advocated the use of the Drummond or lime light, which he proposed to feed with oxygen and hydrogen obtained from water by electrolysis. Limelight is a very intense light radiated from a cylinder of lime rendered incandescent by the flame of an oxy-hydrogen burner. The Drummond light was given a practical trial at the South Foreland high lighthouse in 1862, but according to Sir James Douglass[1] the results were disappointing and so far as lighthouses were concerned the matter was not pursued, although limelight was used extensively for many years as a source of illumination for optical lanterns. The machine Nollet designed was patented in England in 1850 through the medium of E. C. Shepard, his agent. In Shepard's name appear a number of patents connected with the electrolysis project, but there is no doubt that his role was only that of an agent.

The patent granted in 1851 to William Millward of Birmingham for improvements in electromagnetic and magneto-electric apparatus included amongst other



2 *Clarke's magneto-electric machine (about 1834)*

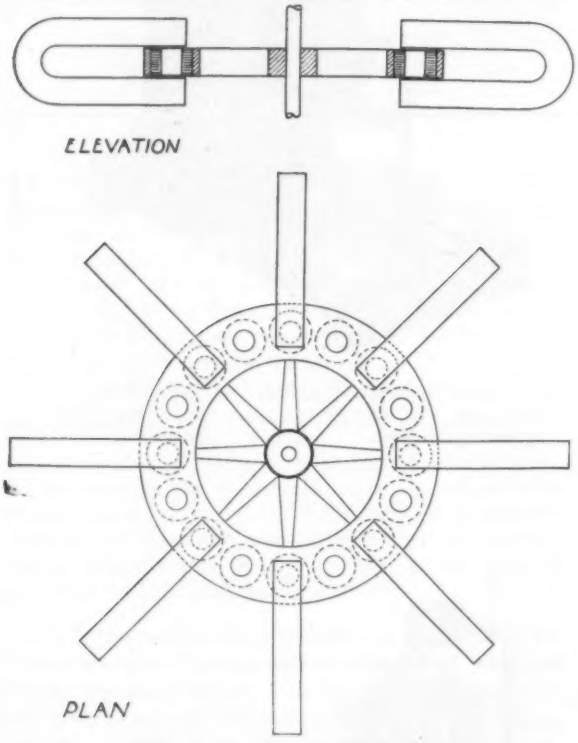
Reproduced by courtesy of the Director of the Science Museum, South Kensington.

3 *Stöhrer magneto-electric machine, 1846*

Crown copyright. From an exhibit in the Science Museum, South Kensington.

things a generator of unique construction. Millward proposed the use of eight U-shaped magnets carried in a frame, equally spaced, arranged with their poles pointing inwards. A disc carrying 16 bobbins was caused to rotate between the poles of the magnets, and the currents thus produced were rectified by a commutator.

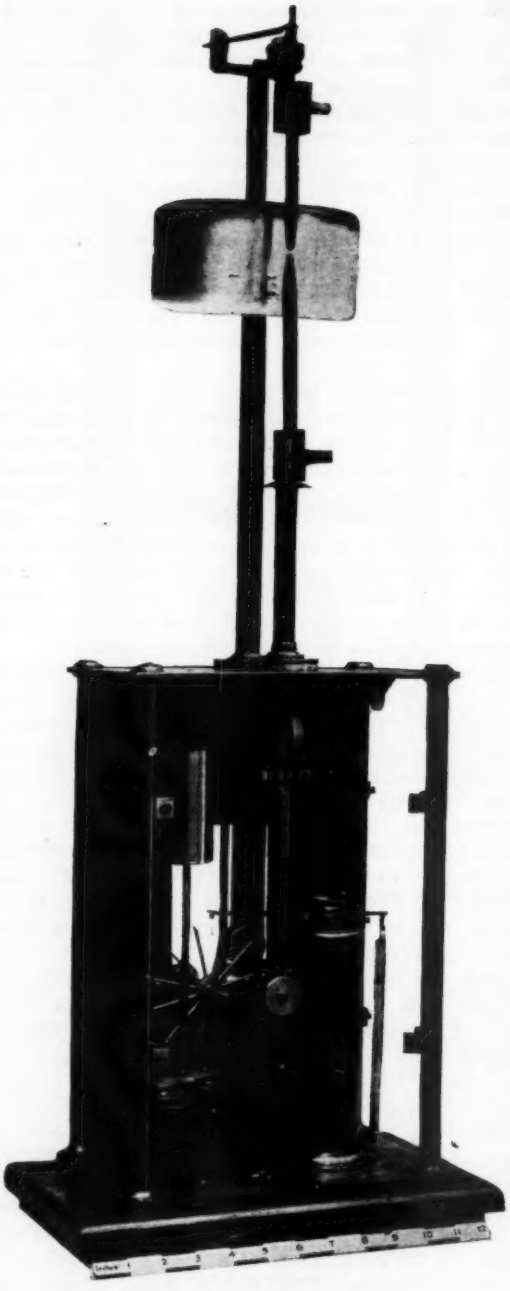
There is no doubt that Nollet would have received details of Millward's patent from Shepard, and it is significant that Shepard was the successful patentee in 1852 of a generator obviously inspired by this source. It could be described as a multiple version of the Millward machine, in which the bank of magnets and the associated



4 *The construction of William Millward's magneto-electric generator, as shown in his patent specification of 1851*

disc was repeated several times, the discs being fixed to a common rotating shaft. The magnets, however, were turned at 90° with respect to their position in Millward's machine, so that the coils rotated in a plane parallel with the side of the magnet, as in Clarke's machines.

Nollet died in January, 1853, before his scheme could be given a full-scale trial, and shortly afterwards (in 1855) an Anglo-French group of financiers formed La Compagnie de l'Alliance. The generators already under construction were completed to the drawings of Nollet and consisted of four rotating discs, each of which carried the 16 bobbins sweeping eight equally



5 *Holmes arc lamp designed for the Dungeness experiments, 1862*

Reproduced by courtesy of the Director of the Science Museum, South Kensington.

spaced U-shaped magnets, all as first proposed by Millward.

The trials proved a fiasco and the company invoked

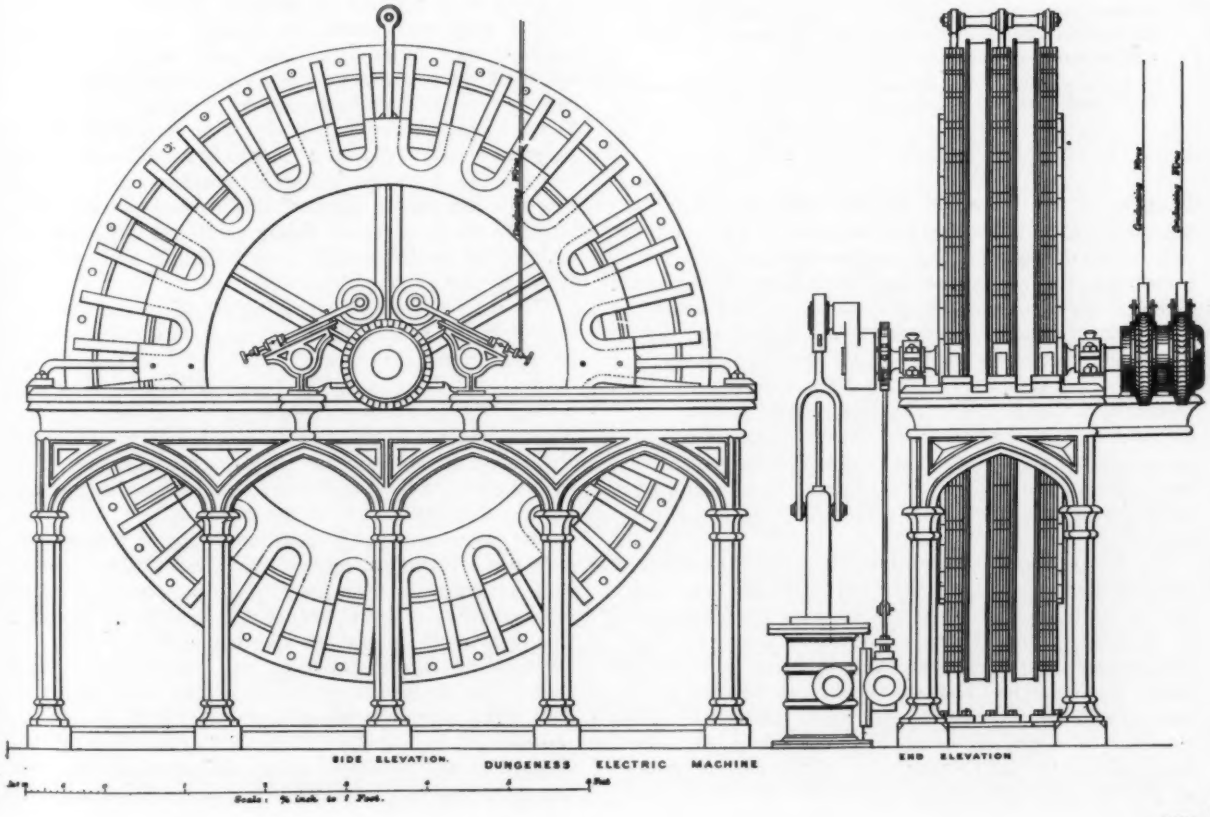
the assistance of several engineers, among whom was Frederick Hale Holmes. Although Holmes was able with modifications to make the generators work, the project proved futile and the Alliance Company was wound up. It was afterwards successfully refloated for the purpose of manufacturing magneto-electric generators to supply the new light, and, as we shall see later, enjoyed success for many years.

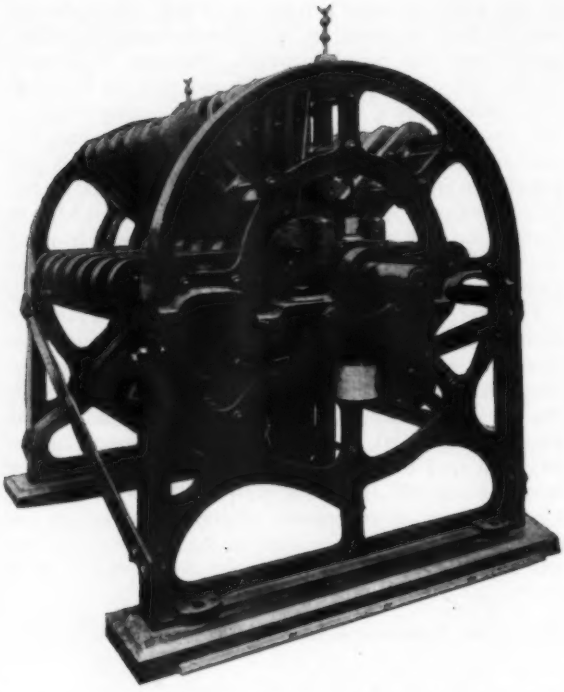
Holmes returned to England about 1856, convinced that by using generators instead of batteries he could make electric arc lighting a success, and in fact he pioneered the electrical illumination of lighthouses in Great Britain. Holmes took out a series of patents for generators from 1856 to 1869, all but the last being of the magneto-electric type and mostly variants on the Alliance machine.

In 1857 he approached the Elder Brethren of Trinity House with definite proposals for the electric illumination of lighthouses by means of his apparatus. The matter was referred to Faraday, who, as scientific adviser to the Corporation of Trinity House, organized an experimental trial between Trinity House Wharf, Blackwall and Woolwich. The machine used for this purpose was of the rotating-magnet type, in which 36 U-shaped magnets were mounted on six rotating discs, uniformly spaced and with poles outwards. Between them were placed five stationary discs, each carrying 24 bobbins, which were swept in turn by the magnets during rotation. The machine was fitted with a commutator and the mechanism was supported on a wooden frame. It was belt-driven from a steam engine at a speed of 600 r.p.m., and it measured roughly 5 ft square in plan, and 4 ft 6 in in elevation, and weighed two tons. The power absorbed was $2\frac{1}{2}$ h.p., so that the output is unlikely to have exceeded 1·5 kW.

Faraday was very impressed with the quality of the light produced, and reported that it was "so intense, so abundant, so concentrated and focal, so free from undershadows and from flickering that one cannot but desire that it should succeed." Upon receipt of what was an encouraging report, the Elder Brethren ordered a further practical trial to take place in the upper lighthouse at South Foreland. For this purpose Holmes designed two machines of an entirely different construction and very much larger. They were of the rotating-coil type, the coils (or helices, as they were then termed), being

6 *Elevation of the Holmes d.c. magneto-electric generator designed for the Dungeness lighthouse, 1862*
Reproduced by courtesy of The Institution of Civil Engineers.





7 *Holmes magneto-electric generator of 1867, exhibited at the Paris Exhibition of the same year. It was in service at Souter Point Lighthouse from 1870 to 1900*

Crown copyright. From an exhibit in the Science Museum, South Kensington.

arranged in two wheels of 80 coils each, carried by a central shaft, on which was also mounted a commutator with roller collectors. The magnets were arranged in three rings of 20 compound magnets each, equally spaced as before with poles pointing outwards. The machines were direct-coupled to non-condensing engines and were driven at a speed of 90 r.p.m. Each generator measured 9 ft 3 in long, 5 ft 6 in wide, and 9 ft 6 in high. The mechanism was supported by a cast-iron frame, and each generator weighed over five tons. According to contemporary records the power absorbed per generator was 2¾ h.p., and thus, on the assumption of an arbitrary efficiency of 85%, the output would have been approximately 1·7 kW.

For the experiments at Blackwall and South Foreland, Holmes used an arc lamp embodying an automatic feed for the carbons, which was manufactured by Duboscq of Paris and which Holmes appears to have modified subsequently. It was customary to have a standby ready for immediate service, under the control of a keeper who was always on duty in the lantern for the purpose of replacing carbons. The light went into operation on the 8th December, 1858, and after a period of trial Faraday reported as follows:

I beg to state that, in my opinion, Professor Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other I have yet seen so applied, and in principle may be accumulated to any degree; its regularity in the lantern is great, its management easy, and its care there may be confided to attentive keepers of the ordinary degree of intellect and knowledge.

Plans were now laid for yet a further trial of the new light at Dungeness. The generators used were similar to those made for South Foreland and were exhibited at the International Exhibition of 1862, which was held in London. The lamps at Dungeness were of a design produced by Holmes in which the rackwork of the Duboscq lamp was replaced by bands of catgut, a step which gave rise to much of the subsequent trouble. The Dungeness equipment went into operation permanently in June, 1862, and remained in service some 13 years.

Meanwhile on the Continent the Alliance machines had built up for themselves an excellent reputation with the French lighthouse authorities. The new Alliance Company was using alternators and had thereby eliminated one source of trouble on these early machines. The Dungeness trials had at first proved far from successful. Light failures were frequent, attributable to various causes, and from time to time the lighthouse had to revert to its original oil burners. For this reason no further step was taken by Trinity House towards changing over other lighthouses until the end of 1866, by which time reassuring reports of the performance of certain French lighthouses were received. In 1867 Holmes designed for Trinity House an alternator of the magneto-electric type, two of which were made under his direction by Messrs. Buckett Brothers, of London. For this machine it is interesting to find that Holmes returned to the original 8-magnet-16-coil arrangement adapted by Nollet in 1853 from Millward and used by the Alliance Company from that time.

The new machines were intended for installation at Souter Point, near Sunderland, and were to be driven by Allen condensing steam engines, of 5 b.h.p. nominal output, manufactured by Sir Joseph Whitworth and Co. Trinity House sent the machinery, Chance Brothers optical equipment and Holmes arc lamps to the Paris Exhibition of 1867, where the light was demonstrated each evening in the Exhibition's lantern, on a temporary tower 120 ft high erected in the grounds.

The generators for Souter Point ran at a speed of 400 r.p.m. Each generator contained 56 compound magnets, arranged in seven rings of eight, between which were six rotating discs, with each disc carrying 16 coils. The generators measured approximately 6 ft long × 4 ft 4 in wide × 5 ft 6 in high, and weighed three tons each. The horse-power absorbed per generator was 3·2, which, again on the assumption of 15% for losses, represented an output of about 2 kVA. For Souter Point, Holmes redesigned his arc lamps, using rackwork instead of the catgut belt and pulleys for the control of

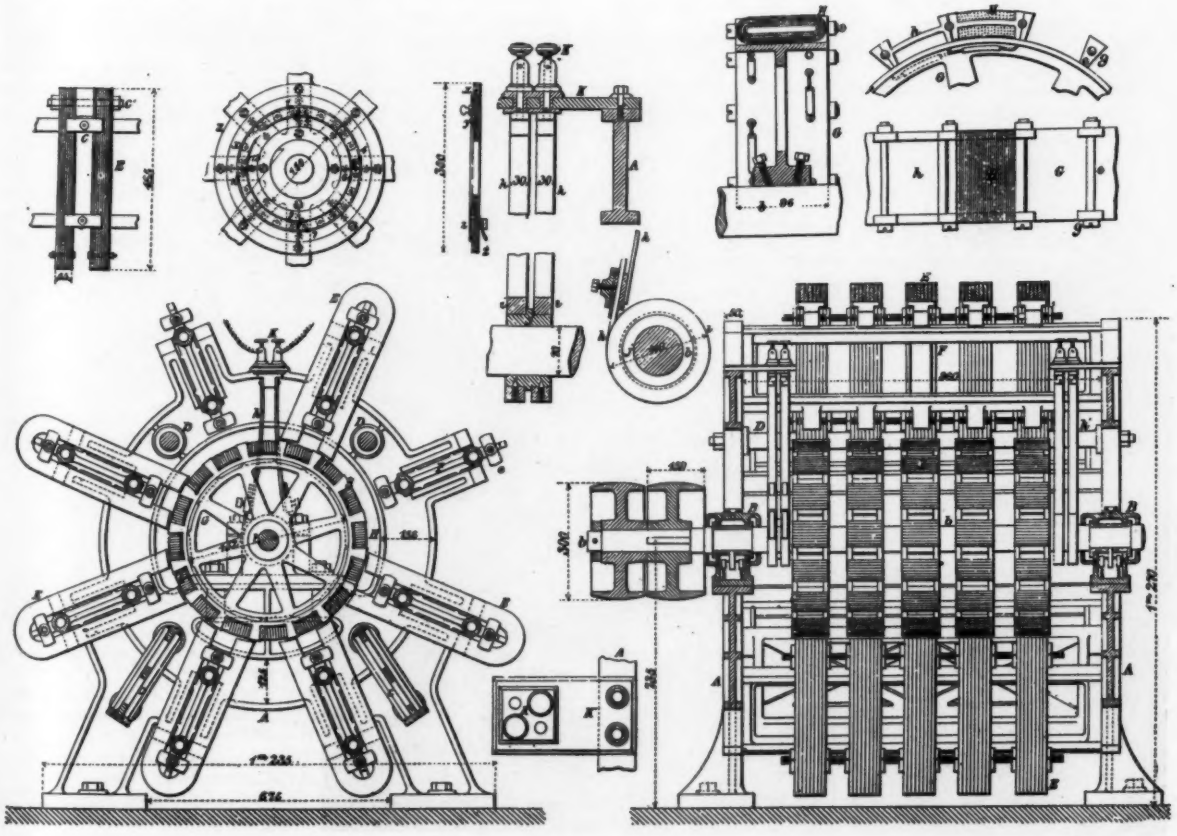
the carbons, and with this he achieved successful operation.

The new lighthouse was completed in 1870 and was working in January, 1871. The Holmes alternators were in continuous service until 1900, and one of them is now exhibited in the Science Museum at South Kensington.

The undoubted success of the electric arc light and associated machinery at Souter Point caused Trinity House to authorize work on a permanent installation at the South Foreland high and low lighthouses. These in common with certain other coastal lights were originally erected in the 17th century, and were fired with coal in braziers until 1792–93, when sperm-oil burners were introduced. It is not proposed to deal here with the development of dynamo-electric machinery for the new light, but it is necessary to say that, although not hitherto adopted for lighthouse work in Great Britain, satisfactory machines were being produced, and Holmes made use of the electromagnetic principle in 1869 to construct for Trinity House a machine of this type. Size for size its output was very much greater than that of a permanent-magnet machine. Prolonged experiments supervised by Professor Tyndall, who had succeeded Faraday as scientific adviser to Trinity House, took place at Blackwall. In the course of these it was found that the new machine could be made to supply one, or two, arc lamps, as required, producing a light of great intensity far exceeding anything previously witnessed. The generator, which was built in accordance with Holmes's patent of 1868, developed excessive heating, and it was not considered safe to proceed. Instead, therefore, four further magneto-electric alternators of the design employed for Souter Point were ordered, together with arc lamps made to Holmes's latest design. Some idea of the improvement in the illumination provided at South Foreland may be obtained from the following figures quoted by Sir James Douglass,[1] formerly Chief Engineer to Trinity House:

The combined intensity of the flame of the four wick lamps previously used in the high lighthouse, and the flame of the 15 Argand oil burners used in the low one, was	477 candles.
The aggregate intensity of the two electric lamps was:	
Minimum	3000 candles.
Maximum for 720 hours	6000 candles.

8 *De Meritens magneto-electric generator, 1881*
Reproduced by courtesy of *Engineering*.



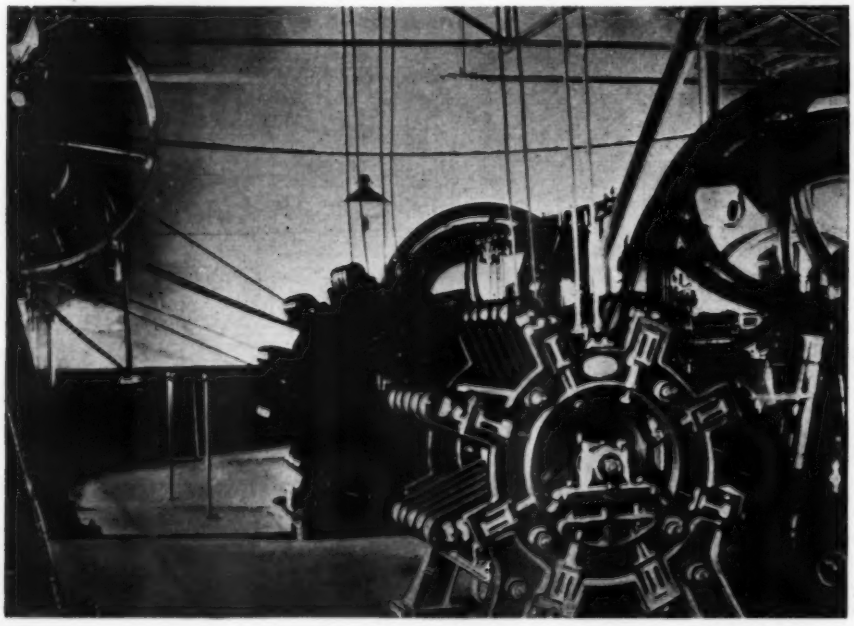
When in 1873 the Corporation of Trinity House decided upon the electrification of the Lizard lighthouse, it was arranged to provide six Siemens dynamo-electric machines in place of the Holmes magneto-electric machines which had hitherto been used in Great Britain. This step was in keeping with the practice in France, where the Administration des Phares had dropped the Alliance magneto machines in favour of Gramme dynamos for lighthouse work. It will be appreciated that the reason for this trend was that it gave an enormous saving in price, dimensions and weight for the same output. Some comparable figures are:

	Type	Speed	Approx. output	Weight	Cost
		r.p.m.	kW	cwt	£
Magneto-electric					
Holmes	A.C.	400	2	51	550
Alliance	A.C.	400	2·3	36	494
Dynamo-electric					
Gramme 1873 model	D.C.	420	3·2	25	320
Siemens 1873 model	D.C.	480	5·5	11	265

These figures would appear to indicate that the magneto-electric machines had had their day, yet within less than a decade the position had once more been reversed. Another pioneer, Baron A. de Meritens, entered the field with a range of machines, which while retaining the simplicity of the magneto-electric arrangement, utilized a distributed rotor winding in place of the bobbins employed by Holmes and the Alliance Company. Furthermore, the cores on which the windings were carried were laminated and the construction generally was of much sounder design. For lighthouse work de Meritens used 40 permanent magnets grouped in 5 banks of 8, arranged with the poles pointing inwards.

The rotor windings and cores were carried on the periphery of spoked wheels, the construction resembling that of the slow-speed alternators of later days. The windings were divided into 16 sections on each of the five wheels, which rotated immediately *below* the poles of the magnets and not *between* successive banks of magnets as in the Holmes and Alliance machines. The windings were brought out to multiple slip-rings mounted on the shaft and were paralleled according to the output desired. The waveform was vastly improved, and for the first time a continuous output, as distinct from a series of pulses of short duration, was achieved.

The generators of Messrs. A. de Meritens of Paris first came into prominence in 1880, but at the Paris Exhibition of 1881 there were no fewer than six lighthouse generators in operation serving Serrin arc lamps and optical equipment made by Messrs. Sauter-Lemonnier. The approximate dimensions of the standard lighthouse machine were 5 ft long by 4 ft 6 in wide by 4 ft 6 in high, and the weight was rather less than two tons. The new design quickly established itself, and in France replaced Alliance machines in most of the lighthouses in which they had been installed. Trinity House ordered the new machines for South Foreland and the Lizard, where, according to Bowen,[2] they were still in operation in 1947. De Meritens machines were also ordered by Trinity House for the Australian lighthouse at Port Macquarie, New South Wales. From figures quoted by Hopkinson[3] it would appear that the generators delivered an output of 4·5 kVA when run at a speed of 830 r.p.m., but this is not necessarily the maximum of which they were capable.



9 *Interior of the machinery room at the Lizard lighthouse, showing de Meritens magneto-electric machines which were in continuous service from 1882 to 1948*

Reproduced from "British Lighthouses" by the late Sir John Bowen (Longmans, 1947).

References

1 DOUGLASS, J. N.: "The Electric Light applied to Lighthouse Illumination," *Proceedings of The Institution of Civil Engineers*, 1878–79, Part III, 57, p. 77.

2 BOWEN, J. P.: "British Lighthouses" (Longmans, for the British Council, 1947).

3 HOPKINSON, DR. J.: "The Electric Lighthouses of Macquarie and of Tino." *Proceedings of The Institution of Civil Engineers*, 1886–87, Part I, 87, p. 243.

The Honorary Secretaries' Conference

SOME 25 years ago an informal meeting of the Honorary Secretaries of the Local Centres was held in London, to give them an opportunity for discussing matters of common interest, to assist them in their work for The Institution, and to allow them to meet the full-time staff in London. In view of the great developments which have since taken place in The Institution's activities, and consequently in the work which falls upon Local Secretaries, the holding of a Conference every year has now become established. It is, of course, attended also by the Honorary Secretaries of the various Sub-Centres and the Irish Branch.

The most recent of these meetings took place in the Institution building in February of this year at the time of the Annual Dinner, which enabled Local Secretaries to be at Grosvenor House for that function without making a separate journey to London. There were 22 Officers present, and before the Conference dispersed the photograph reproduced here was taken. Despite the modest objections of the Secretary of The Institution, and his ingenious reasons why one of the Honorary Officers should take the chair at the Conference, it was the unanimous wish of all except him that he should do so. Also present from the Secretariat were the Assistant Secretary, Mr. F. C. Harris, and Mr. L. H. Cullingford, who acted as secretary to the meeting.

Throughout the Conference, which started at 2 p.m. on Thursday, February 24th, and finished after lunch the next day, there was an extensive exchange of information and ideas on many diverse matters, not only points of principle and policy concerning meetings, social functions, and publications, but also details that arise almost daily in the "office" part of the work of Local Secretaries. At lunch-time on the second day, Mr. Brasher introduced to the Local Secretaries the Heads of the various Departments in The Institution's Secretariat before adjourning the meeting.

For those Honorary Secretaries who have attended a previous Conference, this annual meeting is useful in enabling them to keep in touch with each other, and up to date with Institution affairs, and for the newcomers it is even more valuable, providing as it does a chance to meet their colleagues from other parts for the first time and to compare notes. Always a pleasant feature of these Conferences is the fleeting emergence, at unexpected points in the discussion, of local characteristics—not only the north contrasting with the south, but also the east with the west.

At the end of the meeting a vote of thanks was proposed to the Chairman and to the members of his staff. In replying, Mr. Brasher acknowledged the appreciation which had been expressed for the Conference arrangements, and emphasized that the interchange of ideas and opinions was as valuable to himself and his staff as to the Honorary Secretaries of the Centres.

R. G. L. R.

BACK ROW. G. B. Devey (*South-Western S.C.*); J. D. Ferguson (*Irish Branch*); G. L. Doig (*North Scotland S.C.*); J. L. Egginton (*South-East Scotland S.C.*); T. S. Wylie (*Northern Ireland C.*); A. T. Crawford (*North-Eastern C.*); E. Bolton• (*North Staffs S.C.*); R. G. L. Ryan (*East Midland C.*); L. H. Cullingford (*Staff*).

MIDDLE ROW. H. W. Housley (*Southern Centre*); J. Harley [*West Wales* (*Swansea*) *S.C.*]; G. I. Thomas† (*South-East Scotland S.C.*); E. S. Hall (*Rugby S.C.*); R. L. Stanley (*South-West Scotland S.C.*); W. G. Friggens (*North Staffs S.C.*); H. G. Harlow (*North Midland C.*); C. E. Smith (*North Lancs S.C.*); J. W. Lynn (*Mersey and North Wales C.*).

FRONT ROW. F. C. Harris (*Assistant Secretary, I.E.E.*); F. F. Freeling (*Western C.*); J. H. P. de Villiers (*Scottish C.*); W. K. Brasher (*Secretary, I.E.E.*); T. T. Evans (*North-Western C.*); E. H. Cox (*South Midland C.*); J. A. Walker (*Sheffield S.C.*).

C = Centre. S.C. = Sub-Centre. • Honorary Assistant Secretary. † Honorary Secretary elect.

The Annual Dinner

THE Annual Dinner of The Institution was held at Grosvenor House, Park Lane, on Thursday, 24th February, 1955, when the President, **Mr. J. Eccles, C.B.E., B.Sc.**, presided over a gathering of nearly 1 400 members and guests. Among those present were:

The Rt. Hon. Sir Raymond Evershed, P.C. (*Master of the Rolls*); His Excellency Mr. M. Ikramullah (*High Commissioner for Pakistan*); Sir Gilbert Rennie, G.B.E., K.C.M.G., M.C. (*High Commissioner for the Federation of Rhodesia and Nyasaland*); The Rt. Hon. the Viscount Woolton, P.C., C.H. (*Chancellor of the Duchy of Lancaster*); The Rt. Hon. Nigel Birch, M.P. (*Minister of Works*); The Rt. Hon. Geoffrey Lloyd, P.C., M.P. (*Minister of Fuel and Power*); The Rt. Hon. Lord Citrine, P.C., K.B.E. (*Chairman, British Electricity Authority*); Councillor J. Gordon Elsworthy, J.P. (*The Rt. Worshipful Mayor of the City of Westminster*); The Rt. Hon. the Earl of Halsbury (*Chairman, Advisory Council, Science Museum; Managing Director, National Research Development Corporation*); The Rt. Hon. the Earl of Mount Edgcumbe, T.D. (*Past-President; Honorary Member*); The Rt. Hon. the Viscount Falmouth (*Past Member of Council*); The Rt. Hon. Lord Adrian, O.M., F.R.S. (*President, The Royal Society*); General Sir Brian Robertson, Bt., G.C.B., G.B.E., K.C.M.G., K.C.V.O., D.S.O., M.C. (*Chairman, British Transport Commission*); Sir Noel Ashbridge, B.Sc.(Eng.) (*Past-President*); Sir George Bailey, C.B.E. (*President, The British Electrical and Allied Manufacturers' Association*); Professor Sir Lawrence Bragg, O.B.E., M.C., F.R.S. (*Fullerian Professor of Chemistry and Director of the Davy Faraday Research Laboratory, The Royal Institution of Great Britain*); Sir Frederick Brundrett, K.B.E., C.B. (*Chairman, Defence Research Policy Committee, and Scientific Adviser to the Minister of Defence*); Sir David Brunt, M.A., Sc.D., F.R.S. (*Secretary, The Royal Society*); The Rt. Hon. Sir Alexander Cadogan, O.M., G.C.M.G., K.C.B. (*Chairman, British Broadcasting Corporation*); Rear-Admiral (L) Sir Philip Clarke, K.B.E., C.B., D.S.O. (*Director, Naval Electrical Department, Admiralty*); Sir Roger Duncalfe (*President, The British Standards Institution*); Sir Harold Emmerson, K.C.B., K.C.V.O. (*Permanent Secretary, Ministry of Works*); Sir Ernest Fisk (*Honorary Member*); Sir Arthur P. M. Fleming, C.B.E., D.Eng., LL.D. (*Past-President; Honorary Member*); Sir Archibald J. Gill, B.Sc.(Eng.) (*Past-President*); Sir John Hacking (*Past-President; President, The British Electrical Development Association*); Air Marshal Sir Donald Hardman, K.C.B., O.B.E., D.F.C. (*Air Member for Supply and Organization, Air Ministry*); Sir James Helmore, K.C.B., K.C.M.G. (*Permanent Secretary, Ministry of Supply*); Sir Laurence Helsby, K.B.E., C.B. (*First Commissioner, Civil Service Commission*); Sir Frank Lee, K.C.B., C.M.G. (*Permanent Secretary, Board of Trade*); Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.Sc. (*Member of Council*); Admiral of the Fleet Sir Rhoderick R. McGrigor, G.C.B., D.S.O. (*First Sea Lord and Chief of Naval Staff*); Sir John Maud, G.C.B., C.B.E. (*Secretary, Ministry of Fuel and Power*); Sir George H. Nelson (*Vice-President*); Sir Harry Pilkington (*President, Federation of British Industries*); Sir David Pye (*Past-President, The Institution of Mechanical Engineers*); Sir Gordon Radley, C.B.E., Ph.D.(Eng.) (*Vice-President*); Sir Harry Railing, D.Eng. (*Past President; Honorary Member*); Sir Henry Self, K.C.B., K.C.M.G., K.B.E. (*Deputy Chairman, British Electricity Authority*); W. G. Agnew, C.V.O. (*Clerk of the Council, Privy Council*); Dr. W. N. Arnquist (*Scientific Liaison Officer, Office of Naval Research, American Embassy*); J. R. Beard, C.B.E., M.Sc. (*Past-President; Honorary Member*); J. Bennett (*Member of Council*); J. I. Bernard, B.Sc.Tech. (*Chairman, Utilization Section*); H. Bishop, C.B.E., B.Sc.(Eng.) (*Immediate Past-President*); A. R. Blandford (*Chairman, South Midland Centre*); Dr. W. T. K. Braunholtz, O.B.E., M.A. (*Secretary, The Institution of Gas Engineers*); F. Bray, C.B. (*Under-Secretary, Ministry of Education*); Professor H. V. A. Briscoe, D.Sc. (*Vice-President, The Royal Institute of Chemistry*); G. Caton (*Past-Chairman, North Midland Centre*); T. Coates, M.Eng. (*Past-Chairman, Mersey and North Wales Centre*); A. Cooper (*Surveyor of Lands, Duchy of Lancaster*); A. R. Cooper (*Member of Council*); E. H. Cox (*Hon. Secretary, South Midland Centre*); A. T. Crawford, B.Sc. (*Member of Council; Hon. Secretary, North-Eastern Centre*); Rev. C. L. Cresswell, C.V.O., M.A. (*Chaplain of the Queen's Chapel of the Savoy; Chaplain to The Institution*); C. E. T. Cridland (*President, The Scientific Instrument Manufacturers' Association*); C. Dannatt, O.B.E., D.Sc. (*Member of Council*); G. B. Devey (*Hon. Secretary, South-Western Sub-Centre*); J. H. P. de Villiers (*Hon. Secretary, Scottish Centre*); G. L. Doig, B.Sc.(Eng.) (*Hon. Secretary, North Scotland Sub-Centre*); P. R. Dunn, B.Sc. (*Chairman, Mersey and North Wales Centre*); J. L. Egginton, B.Sc. (*Hon. Secretary, South-East Scotland Sub-Centre*); T. T. Evans (*Hon. Secretary, North-Western Centre*); J. D. Ferguson, B.Sc. (Eng.) (*Hon. Secretary, Irish Branch*); J. H. Fraser, O.B.E., T.D. (*President, The Institution of Railway Signal Engineers*); F. F. Freeling (*Hon. Secretary, Western Centre*); W. G. Friggens, B.Sc.(Eng.) (*Hon. Secretary, North Staffordshire Sub-Centre*); H. J. Gibson, B.Sc. (*Past-Chairman, South Midland Centre*); T. E. Goldup, C.B.E. (*Vice-President*); S. E. Goodall, M.Sc.(Eng.) (*Vice-President*); H. W. Grimmitt (*Honorary Treasurer*); T. G. N. Haldane, M.A. (*Past-President; Chairman, Association of Consulting Engineers*); E. S. Hall (*Hon. Secretary, Rugby Sub-Centre*); J. Harley [*Hon. Secretary, West Wales* (*Swansea*) *Sub-Centre*]; H. G. Harlow, B.Sc.(Eng.) (*Hon. Secretary, North Midland Centre*); J. Vaughan Harries (*Past-Chairman, Western Centre*); K. Headlam-Morley (*Secretary, The Iron and Steel Institute*); H. W. Housley (*Hon. Secretary, Southern Centre*); O. W. Humphreys, B.Sc (*Member of Council*); W. K. Hutchison, C.B.E. (*Vice-President,*

The President, the Master of the Rolls, and the Chancellor of the Duchy of Lancaster, before dinner

The Master of the Rolls proposing the toast of The Institution

The Institution of Gas Engineers); Dr. W. Idris-Jones, B.Sc. (*President, The Institute of Fuel*); A. N. Irens (*Chairman, Western Centre*); Willis Jackson, D.Sc., D.Phil., F.R.S. (*Vice-President*); F. H. Jessop, LL.B. (*President, The Law Society*); C. R. King, C.B.E. (*Member of Council*); F. J. Lane, O.B.E., M.Sc. (*Member of Council*); T. Lawrie (*General Manager, North of Scotland Hydro-Electric Board*); Colonel B. H. Leeson, C.B.E., T.D. (*Past-President*); E. Leete (*Honorary Member*); E. C. Lennox (*President, The Illuminating Engineering Society*); A. W. Lineker (*Past-President, The South African Institute of Electrical Engineers; Oversea Representative of the Council for the Transvaal*); E. A. Logan, M.Sc. (*Chairman, Southern Centre*); G. S. C. Lucas, O.B.E. (*Member of Council*); T. G. Lund, C.B.E. (*Secretary, The Law Society*); J. W. Lynn, M.Sc. (*Hon. Secretary, Mersey and North Wales Centre*); The Hon. R. G. Lyttleton (*President, The Iron and Steel Institute*); Dr. A. Macrea, M.A. (*Secretary, British Medical Association*); A. McDonald, B.Sc. (*Secretary, The Institution of Civil Engineers*); R. F. Marriott (*Advisory Engineer to the High Commissioner for New Zealand*); Dr. D. C. Martin, B.Sc. (*Assistant Secretary, The Royal Society*); Professor H. S. W. Massey, B.A., Ph.D., F.R.S. (*President, The Physical Society*); B. L. Metcalf, B.Sc.(Eng.) (*Past-Chairman, Utilization Section*); G. W. B. Mitchell, B.A. (*Chairman, North-Eastern Centre*); J. H. Mitchell, B.Sc., Ph.D. (*Chairman, East Midland Centre*); Professor E. B. Moullin, M.A., Sc.D. (*Past-President*); J. Muil (*Registrar and Secretary, Professional Engineers Appointments Bureau*); A. H. Mumford, O.B.E., B.Sc.(Eng.) (*Member of Council*); C. W. Oatley, M.A. (*Chairman, Radio Section*); W. F. Parker (*Member of Council*); P. Parr, O.B.E., B.Sc. (*President, The Institution of Municipal Engineers*); J. D. Peattie, B.Sc. (*Chairman, Supply Section*); A. F. Plummer (*President, The Electrical Contractors' Association*); B. G. Robbins, M.Sc.(Eng.) (*Secretary, The Institution of Mechanical Engineers*); A. Rusck (*President, Swedish State Power Board*); J. Ryan, C.B.E., M.C. (*Chairman, The British Standards Institution*); R. G. L. Ryan (*Hon. Secretary, East Midland Centre*); Professor M. G. Say, Ph.D., M.Sc. (*Member of Council*); W. E. Schall, B.Sc. (*Chairman, The Society of X-Ray Technology*); J. A. Smale, C.B.E., A.F.C., B.Sc. (*Past-Chairman, Radio Section*); C. E. Smith, B.Sc.(Eng.) (*Hon. Secretary, North Lancashire Sub-Centre*); G. Darnley Smith, C.B.E. (*Chairman, Radio Industry Council*); W. Lewis Smith (*Chairman, The Cable Makers' Association*); R. Somerville, C.V.O. (*Clerk of the Council, Duchy of Lancaster*); R. L. Stanley (*Hon. Secretary, South-West Scotland Sub-Centre*); D. D. Walker, M.A. (*Chairman, The British Electrical and Allied Manufacturers' Association*); J. A. Walker (*Hon. Secretary, Sheffield Sub-Centre*); D. M. Watson, B.Sc. (*President, The Institution of Civil Engineers*); G. O. Watson (*Member of Council; Principal Electrical Engineer Surveyor, Lloyd's Register of Shipping*); H. West (*Past-Chairman, North-Western Centre*); Major-General M. S. Wheatley, C.B., C.B.E. (*Director of Signals, War Office*); M. Whitehead (*Chairman, Measurements Section*); C. D. Wilkinson (*Past-Chairman, East Midland Centre*); Dr. H. F. Willis, M.Sc. (*Chief of the Royal Naval Scientific Service*); J. G. Winnard (*Hon. Secretary, Tees-Side Sub-Centre*); T. S. Wylie (*Hon. Secretary, Northern Ireland Centre*); R. T. B. Wynn, C.B.E., M.A. (*Member of Council*); and W. K. Brasher, C.B.E., M.A. (*Secretary*).

The Dinner began with Grace said by the **Rev. C. L. Cresswell, C.V.O., M.A.,** Chaplain to The Institution, in the following words:

"For these and all the blessings of God's providence in our daily life: for our fellowship one with another, and for the work, sacrifice and service which this Institution gives in helping to provide the many great discoveries of science in our age; for these and all Thy bounties, we yield Thee humble and hearty thanks, beseeching Thee to give us grace rightly to use them to Thy glory and the good of all mankind. Amen."

The Loyal Toasts, proposed by the President, having been honoured, **The Rt. Hon. Sir Raymond Evershed, P.C.,** Master of the Rolls, proposed the toast of "The Institution of Electrical Engineers." He said:

"Her Majesty's Ministers will forgive the absence of a separate reference to them. Her Majesty's Judges are rather sensitive about undue adulation of the Executive.

"You have here indeed a very dazzling gathering, and I shall not forget that this is a dinner of The Institution of Electrical Engineers and not, for example, a branch meeting of the Electrical Trades Union! The more cynical of your guests, if such there be after so lavish hospitality, might regard it as slightly sinister that he whom you have honoured by your invitation to propose this toast should be one who was by training an advocate and who is by nature wholly allergic to electricity. But let me assure you, Sir, that The Institution of Electrical Engineers requires no advocate to commend it. Nor should you assume that there was any purpose in asking someone wholly ignorant of your art to propose your toast. I am indeed a little conscious of being somewhat

of a backslider, because I think that there is—there certainly was—an instrument known as Evershed's ohmmeter, which I understood was designed to register, very faithfully of course, resistances in electricity. I do not believe it has ever been applied to registering resistances in other walks of life.

"I have myself been always fascinated by the use which has been made of individual names in electricity—Ohm, Volta, Ampère, and all the rest of them. For myself, hundreds of years ago I learned that the Greek term 'electron' meant amber, and somebody still longer ago discovered that if you rubbed it, it attracted little particles to itself. I have an idea that 'electron' to-day implies something more red than amber. Indeed, it is a fact that the great majority of mankind stands somewhat in terror of the electronic brain and all the other frightful things that electrical engineers have invented or have learnt. The rest of mankind find themselves retreating with ever-increasing speed from what Morgan Forster once described as the implacable offensive of science. Mr. President, the times in which we live are notoriously terrifying and things change hideously almost one might say from hour to hour. It was Pope, was it not, who said:

Nature, and Nature's laws, lay hid in night,
God said, 'Let Newton be!' and all was light.

Then somebody completed it by saying:

It did not last: the Devil howling 'Ho,
Let Einstein be,' restored the *status quo*.

"To say that we live in an age of transition is itself perhaps nothing very new. According, I believe, to Dean Inge, when Adam and Eve left the Garden of Eden in circumstances which were rather depressing to them both, Adam is said to have remarked to Eve, 'My dear, we must realize that we live in an age of transition!' But these rather terrifying things I know are not to you terrifying at all. It is all to you no doubt an open, well-read book, well understood; but we, the great majority of mankind, do feel sometimes just a little afraid. We are afraid because we wonder whether the technologists have too great an advantage over the rest of mankind. We sometimes imagine that a party of members of The Institution of Electrical Engineers might occupy a little island, and, from that starting-point and without any great difficulty to themselves, by the use of devilish instruments of one kind or another subdue to their will the rest of humanity. Judging from the kind of hospitality that we have all received to-night, I daresay the world so governed by a chosen few members of The Institution of Electrical Engineers would not be so bad after all! But you will forgive us if we feel a bit uneasy—just in case you were slightly less kind in those circumstances than you are in the Great Room of Grosvenor House.

"So I am led to suggest to you that The Institution itself should provide—and indeed does provide—the consolation to our rather frightened minds; for you, I know, will never forget that you are members of a profession. I am also a member of a profession. Although I have for a time, the length of which I do not like altogether to remember, sat on the Bench, I still like to think of myself as a member of the profession of the Bar, and I find near to me distinguished members of different professions, of the Fighting Services of the Crown, of the Civil Service, of the Law Society and of others. We all of us have throughout our professional lives been conscious not only of the tremendous debt which we owe for what our profession has given us, but of the tremendous obligation to our profession which throughout our lives must constantly press upon us.

"Any professional man, I suggest to you, must always have in mind that in all that he does relating to his profession there is no standard which can be too high. It is because of this that I think The Institution does not serve only a great purpose to its members, but an equally great comfort and assurance to the rest of mankind. For if you are in truth a loyal member of a professional body, you never forget that in all the work which you do you owe an obligation above all else through your profession to the rest of mankind and also to your own conscience. I venture—and I hope that I am not being too solemn on this occasion—to commend that very serious thought to you, and in wishing The Institution every possible good will to bear in mind that that is above all else what it does for electrical engineers—it gives them the pride, the integrity and the justification which belong to professional men.

"As an Institution you are some two years older than the Supreme Court of Judicature and that, of course, is a very solemn thought. It is the fact that when the late Mr. Gladstone, whose sayings in my youth it was always popular to quote, introduced the Supreme Court of Judicature Act, he was at the same time telling the electors in this country that if he were returned to power—as you will remember he was not—he would abolish the income tax. Allowing for a little margin of a year or two, the birth of The Institution of Electrical Engineers, the creation of the Supreme Court of Judicature and the unhappy perpetuity of the income tax are all very much mixed up together. All three have acquired respectability and traditions. There is one other consideration I should like to commend to you and it is this. However absorbing your professional studies may be and however tremendous may be the capacity required—and it does seem to me indeed a tremendous capacity that is necessary for absorbing the requirements of professional status in electrical engineering—do not ever forget that knowledge of this particular branch of applied science is but a part of the total sum of human knowledge, and that if it is to render its most useful service to mankind it must always be in its proper relation to the rest of human knowledge, and also to the spiritual and emotional in man without which the human being is nothing. Without that relationship it is in truth neither knowledge nor wisdom but mere technique at most.

"In suggesting to you that particular reflection I can, I am quite sure, do no better than rely upon some of your

most distinguished members in the past. I take for my text in this respect the saying attributed to John Hopkinson: 'What is wanted is not to depend upon mathematics alone, but to have a general appreciation whether a thing looks about right.' If I may here stray a little from my honorific duty I should like to invite you to extend to me a moment of sympathetic thought; for it has been my duty and privilege during the last week or so, presiding in the Court of Appeal, to hear the Revenue List, and the technicalities of the Finance Act are almost equal in complexity to some of the more recondite principles of electrical engineering. Every now and then when I have been listening to the arguments put before us I like to say to myself, borrowing as I shall henceforth do, the words of your own illustrious progenitor John Hopkinson: 'What is wanted is not to be dependent upon the Finance Acts alone, but to have a general appreciation whether the thing looks about right.' Of course for me there are always the corrective possibilities presented by the House of Lords, those persons to whom the late Lord Justice MacKinnon referred as the 'infallible voices'! But still, a little common sense now and again is worth trying, is it not?

"It is my very great privilege as your honoured guest now to invite this great and illustrious assembly to wish all possible good things to your Institution. I should only like personally to say that I feel indeed proud to have been honoured by you in this duty. I live in a part of England which has always been regarded as a bit remote, and which suffers in a remarkable degree from the most hideous convulsions of nature. I refer to that almost independent sovereign state known as the County of Norfolk. Through you, Sir, may I express as I should like to do my appreciation of the trouble and care taken by the Area Board to look after the creature comforts not only of myself but also of the animal population of the small plot of land which I occupy in that somewhat remote part of England.

"My Lords and Gentlemen, I ask you now to join with me in drinking the health of The Institution. We wish it every prosperity. I know that you will agree with me in hoping that it will continue to bring to all its members that great inspiration which its history has very well provided in the past."

The **President,** in response, said:

"As I think you know, Sir Raymond, it is our custom to invite to these annual gatherings a distinguished representative of the Church or State, of law or medicine, or of the aural or visual arts to be our principal guest. To-night we consider ourselves to be extremely fortunate that you have so kindly consented to be with us in this way, and may I on behalf of all the members express thanks not only for your presence here, but for the words of wisdom and encouragement which you have just spoken.

"For myself, having always lived, as it were, just on the fringe of the law, I know sufficient about it to run my business and to avoid too frequent appearances in the courts! I must, however, confess that modern statutes have become so complex that I, in common with most people in this room—Her Majesty's Ministers always excepted—have probably broken some law or regulation every day. Someone said the other day that only a legally trained person could do right nowadays. My knowledge of the law extends to a general awareness of the exalted position which you, Sir, hold on the very summit of your profession. I also know that the continued existence of your office is proof, if it were needed, that you are not in any way connected with an erstwhile Ministry of Food!

"Notwithstanding your remarks about the relative youth of the Supreme Court of Judicature, yours is a very old profession. Your roots are so grounded in antiquity that that time-honoured phrase 'The Law and the Prophets' might easily be misconstrued in this commercial

Mr. Bishop, Lord Woolton, Sir Raymond Evershed, and Mr. Eccles

age! Be that as it may, the priest and the prophet, the lawgiver and the seer were at one time often one and the same person, and fortunate it is for us that almost equally often that person was one who had high principles and abundant common sense. It must have been a great responsibility to be the oracle of deity, particularly since there was no risk of being hauled over the coals at question time, and that position must have carried with it a great temptation to exploit it for self-interest. On the whole your ancestors resisted that temptation, and instead they produced rules of conduct and procedure which, although designed in detail for their day and generation, have within them the principles of good government applicable to all time.

"Now times have changed. We entrust law-making to the representatives of the people and the administration and interpretation of law to those other men of high principle and common sense. Probably on the whole it is safer that way, but if it is to remain safe it is important that we should have a judiciary which is quite independent of, and not subservient to, the legislature. The

awful examples that we have had of dictators and dictatorship of the proletariat administering their dicta through subservient peoples' courts should be a lesson and a warning of the real importance of the independence of those who administer the law. Sir Raymond, we welcome you here in your own right. We welcome you also as a distinguished representative of a profession and of a system that has earned our respect, enjoys our goodwill and is one on which our hopes rest.

"In quite another sense we also are men of laws. We certainly have enjoyed the intimacy of the bar—also in another sense! But it is the business of science to discover Nature's laws and it is the business of technology to apply those laws for the use of mankind. (By the way, I think I ought to explain that technology is what we call science when it becomes useful.)

"Our laws are certainly different from yours. Ours are the immutable expression of an unknown cause, and in that sense we are also the oracles of a deity, but with this difference, that we suffer the restriction and limitation that our laws must be subject to calculation, verification and cross-check. Our laws also are mainly about things and not people. That gives us an extra degree of freedom because things cannot answer back.

"I think that we differ from you in this respect also, and perhaps most important, that we try to improve upon Nature. We try to use her laws in ways in which she probably never intended, to achieve ends to which Nature never seems to have aspired. Of course we have our darker side. The Marley's ghost of high explosives, poison gas and atom bombs still lurks around, but these are examples of science misapplied, of science in the hands of necessitous non-scientists anxious to take a short cut home.

"However, there is very much more on the credit side. I think it is not too much to claim that but for science as applied through technology the standard of comfort, culture and leisure now enjoyed by masses of the people would have been quite unattainable.

"Nature multiplies her output through fertilizers and irrigation. Machines and vehicles have replaced the work of slaves and helots, and in the home those simple, quiet, clean devices can vanquish drudgery and outlaw toil. This correspondence between hand and brain once started is very difficult to stop. We have just got to keep on going on. If I may quote for a moment from the recent White Paper published by the Government a week ago on the industrial application of nuclear energy, it reads: 'Our future as an industrial country depends both on the ability of our scientists to discover the secrets of Nature and on our speed in applying the new techniques that science places within our grasp.' In this industrial country, if we are to provide an acceptable existence for 50 million people, we require many more scientists and engineers to wrest more secrets from the bosom of Nature and to constrain them to meet man's needs.

"It is surprising how many are the people who do not believe that and who still cling to the idea that by some magical hangover from our great industrial past and our financial power we shall enjoy our proper share of the markets of the world. They seem to think that our reputation is enough. They cannot get into their heads that price, quality and delivery are the main things that matter in this great world, which is bristling with commercial acumen and scientific knowledge. This inertia must be overcome, because we as a country cannot afford to have anything but the best if we are to maintain our place.

Colonel Leeson, Lord Adrian, Lord Citrine, Sir John Hacking, and General Sir Brian Robertson

"In this respect the middle-distance future is not too bright. The nursery of science is in our primary and secondary schools, and at this moment there is a great dearth of science teachers. I know, and I think everyone here knows, that teaching science to boys is a hard task. One has to dispel the romance of space ships and interplanetary travel and get down to the rigorous discipline of the laboratory. That does not go down too well between the ages of 10 and 15. There is also the tendency in some schools to lean towards what they are pleased to call the humanities, as if science were not the greatest humanity of them all. I agree that a classical education is of the greatest value, but I should like to see the introduction of a system wherein every boy with ability in mathematics and an aptitude for mechanics was exposed to the elements of science so that later he would be able to judge and to choose where his future lay. We need more science teachers in our schools and we need an improved and extended system of technical education, if we are to have enough scientists able to think fundamentally and to lead those of more limited perception.

"The recent nuclear programme which has been announced emphasizes and underlines the importance of having first-class men. This need will not be met, if I might use a phrase of Kipling, 'By singing "oh! how beautiful" and sitting in the shade.' It will be met by us, the people, deciding to provide proper remuneration and prospects for the science teachers in schools and technical colleges so that they are at least on a par with those of like attainments in industry. It will be met by the Minister of Education providing a proper basis for the future pattern of technical education, and it will be met

by parents encouraging their children to adopt a scientific career.

"We think—and here I speak for the three engineering Institutions—it is of extreme importance that in the proposals which the Government are making for technical education the students should receive a comprehensive course including mathematics, physics, chemistry and engineering technology, and that they should receive it in colleges which are adequately equipped and competently staffed. The content of the course and the quality of the college are of much greater importance than the title of the award. As we see it we cannot afford to go into the future backwards, as we are apt to do if we listen too long and too often to those who have not yet woken up to the need. We in the three major engineering Institutions are doing all we can to point the way and to maintain a standard. Our advice and help are always available. We believe that it would be a disservice to the country—and here we agree with you, Sir—to lower the requirements for entrance to our membership. Corporate membership of these Institutions confers professional status which is itself a very special thing, and we cannot concur in any proposal which might create or tend to create a crop of sub-standard young men calling themselves engineers who may not be able to qualify for membership of the appropriate Institution.

"We, Sir, are very conscious of what you said earlier that our knowledge is only a part of the sum total of human knowledge. The Institutions are doing something to broaden the outlook of the technologist. We believe most profoundly that it is not sufficient for a man just to edge his way along the crowded pavement of life, but that he should mingle with the crowd and take his place in the government of his country, in the administration of his business or in the local society and community in which he lives. Science and technology harness Nature's laws for man's benefit. It is the constant endeavour of The Institution to increase new knowledge and to disseminate it. Is it not up to each of us to see that the benefits are fairly spread, and that the resultant leisure is used to keep mind and body in a healthy and helpful state?

"It is with these thoughts in mind that we welcome very much indeed the opportunity of meeting and mixing with members of kindred professions as we have been able to do this evening. It is with these thoughts in mind also that I have felt it a very great privilege and pleasure to be permitted to respond to this toast. On behalf of all our members may I express to you, Sir, our warmest thanks for proposing this toast in such gracious and felicitous terms, and may I thank you, my Lords and Gentlemen, for the kindly way in which you have acknowledged it."

Mr. Harold Bishop, C.B.E., B.Sc.(Eng.), immediate Past-President of The Institution, in proposing the toast of "Our Guests," said:

"Before he sinks into complete oblivion the immediate Past-President has the pleasure of proposing the toast of the guests. That is a very high privilege, but nevertheless it is a task to pay tribute to the galaxy of important and, if I may say so, decorative guests whom we have the honour to entertain this evening. If, as we hope, they have enjoyed themselves, our food and even, perhaps, our mental offerings, it is some recompense for their having to face 1 400 boiled-shirted engineers in the mass. This dinner has become a very vast affair, but I do not think that is a sign of any undue prosperity on our part. It is rather one of pleasure in getting together and welcoming our guests. May it continue to be said of us that inasmuch as we understand each other we cannot really disagree.

"A catalogue of our guests and a list of their qualifications would I am sure be irksome and I would be certain to overlook important facts. We like to think that their presence here this evening is a tribute not to the Grosvenor House cooking but to the importance and wide field of application of our profession.

"Particularly am I glad to welcome Her Majesty's Ministers. I find that all but one of them have gone but I still say that. The reason why Lord Woolton has not gone is that he is not subject to a Three-Line Whip! We are particularly happy to have him here to-night because he has always displayed a wide interest in electrical engineering. We respect his great work for the country over many years and the high office which he now holds. In addition we have had the Minister of Fuel and Power and the Minister of Works. We are glad indeed to have had the honour of their company. We ordinary mortals have great sympathy with Ministers of the Crown at this time of the year. They have to attend an untold number of dinners, and how they can avoid the ill effects I really do not know. I am reminded of the small child who described an adult as one who had stopped growing except round the middle! Ministers have a hard life and must never put a foot wrong. They must on the one hand listen to everything we have to say and on the other hand be quite sure that we do what we are told. They must also be diplomatic, and you know that if a diplomat says 'yes' he means 'perhaps,' if he says 'perhaps' he means 'no,' and if he says 'no' then he is no diplomat!

"It is a special pleasure for us to have with us the Mayor of the City of Westminster, in whose parish we work and live. We have with us also the High Commissioners of the Commonwealth, and in these momentous times in world affairs it is extremely important that we, as a professional Institution, should maintain and extend our contacts with our sister Institutions abroad. In 1954 the three major engineering Institutions held in London the Commonwealth Engineering Conference, attended by all the Presidents and Secretaries of our sister Institutions in the Commonwealth. Our discussions with them were of great value to us and I hope to them. We have a common purpose which is to serve the community and to extend the influence of the professional engineer throughout the Commonwealth.

"We also have with us many senior members of the Civil Service and the Fighting Services. Indeed, if you look at them you will, I think, agree that they might well be described as a decoration of senior officials! We always receive the most courteous treatment at their hands and we are grateful to them. Our contacts are on many matters and especially on one which our President has mentioned, namely the education and training of engineers, not merely in a general sense but in particular for the many Departments of State and for the Fighting Services. The Civil Service, the Armed Forces, public authorities and industry are all suffering from a shortage of technologists. The Institution, with the accumulated knowledge of its 39 000 members, is available, able and willing to help in solving this problem. We are glad to have these eminent gentlemen present because it is an indication that they recognize the value of The Institution's work. For our part we hope that the work of the electrical engineer will be increasingly recognized in public administration. This has not always perhaps been so, but we hope that it will be in the future. The production and exports of this country and, in consequence, our standard of living, depend very largely on our trained engineering man-power.

"We also have with us representatives of the nationalized industries, and to some extent I have a personal knowledge of the hard lives these gentlemen lead. They give service to the public, a most forbidding but rewarding task. I should like to mention particularly Sir Brian Robertson, who is present to-night and who has before him the tremendous task of modernizing the railways. In the carrying out of that task, I would assure him, he has the whole electrical engineering profession behind him.

"Our contacts with the learned societies are, of course, very close, and we have with us several of the Presidents and Secretaries of those bodies. I cannot mention them all, but I shall mention one, the Royal Society, the oldest of them all, which received its Charter from Charles II in 1662. May I also at this stage convey a special word of congratulation to its President, Lord Adrian, on the recent honour bestowed upon him by Her Majesty, in this his last year of office.

"The Trade Associations represented here are very close to us indeed. As you all know, the membership of such Associations and of our own Institution is almost a common one. Our work is closely allied to theirs. We are complementary to each other because the technical and industrial potentials of a modern country are vital factors in its commercial and military strength. Between us we must break down, as Sir Raymond Evershed and the President have said, the popular reactions of fear, uneasiness and misunderstandings in the work of the scientist and the engineer. Barriers between conventional academic departments in universities must be destroyed to bring more into the open the beneficent nature of science and of a creative intelligence. There is a great deal to be done in this way, so that we can show that the only way to multiply a valued possession is to divide it.

"I should like to welcome particularly the President of The Institution of Civil Engineers and a Past-President of The Institution of Mechanical Engineers. As many of you know, the three engineering Institutions are continuing to work very closely together, and this, I think, is a very good thing indeed and something that is for our mutual benefit.

"May I mention now another name, that of our Faraday Lecturer, Mr. Terroni. For the benefit of our guests who do not know, the Faraday Lecture is a popular lecture given every year to interest the public in electrical engineering. In the last few months Mr. Terroni has given his quite admirable lecture some 15 times all over the country, and I suppose he has had in the aggregate an audience of something like 25 000 from the general public. That sort of thing is of real value in extending the influence of our profession and making its importance known to the man in the street.

"May I mention also the Honorary Secretaries of our Local Centres and Sub-Centres. They are the absolute backbone so far as our provincial work is concerned. It is all very well for those who live in London to think that London is the only place that counts in the work of The Institution. It is not. Our membership and our work are spread far and wide in this country and indeed over the whole world.

"I mention now our new Honorary Member, Mr. J. R. Beard. We normally elect one Honorary Member a year, and we hope it is regarded as a great honour by the person so elected. We were proud indeed to elect Mr. Beard, who is a Past-President of The Institution and has had an outstanding career in electrical engineering.

"Coming now to our principal guest, I have had a good deal of my thunder stolen by the President. No body of persons commands my more sincere respect, not to say awe, than Her Majesty's Judges. They have a knowledge of human frailty and human nature which is beyond the ken of the ordinary man. I am reminded of the Frenchman who was put on trial for murdering his father and mother and who begged for mercy on the ground that he was an orphan! My knowledge of the law is I am afraid very limited. Indeed, I think it is true to say that were it not for the invention of the motor-car most of us would fail to gain an insight into the legal processes of our courts!

"I need not remind you of the brilliant and eloquent member of the Judiciary who is our principal guest to-night. As a matter of fact I have found out something about his office. He gave an address recently to the Law Society and from that I have learned all about the Master of the Rolls. Briefly the Master of the Rolls looks after the State Records and he has done that since 1471. I am not of course suggesting that our present guest has done it since then. I gather it was found that this was not in itself whole-time employment, and the holder of the office no doubt had difficulty in persuading the efficiency expert of the time that he deserved a rise in pay. So they increased the duties and gave the Master of the Rolls a second job. This time it was really a big

one, and as you know the Master of the Rolls now presides in the Court of Appeal and is in fact third in the judicial hierarchy. I believe also that he is a sort of father or father-in-law to all solicitors. A learned Judge once said, 'Decide promptly but never give any reasons. Your decision may be right but your reasons are sure to be wrong.' Perhaps a barrister has a better life than that. A grateful woman client once said to a barrister, 'How can I ever show my appreciation?' 'Madam,' he replied, 'Since the Phoenicians invented money there has only been one answer to that question.' We are indeed grateful to Sir Raymond for his speech.

"It is my purpose to couple this toast with the name of Lord Citrine. Strictly speaking he is not a guest at all, because he is a Companion of The Institution, and very proud we are to have him in that capacity. To-night, however, we welcome him as a guest, and we pay tribute to the great job that he has done as Chairman of the B.E.A. since 1947. As such, of course, he has a very close link indeed with our President. Lord Citrine is not only a great reader but he is also a great writer. He has had an outstanding career, particularly his work for the T.U.C. over some 22 years, and he commands our sincere respect. He is a man of reason and calm judgment, qualities which are so necessary for leadership. He is a great master of his craft and to everyone an example, a pattern and an inspiration. Under his guidance the B.E.A. is doing great work, and you have all read about the increase in its responsibilities arising from the development of nuclear power production, which has been announced in recent weeks. It is a tremendous job for the B.E.A. which will take a long time to carry out. But with Lord Citrine in charge and, if I may say so in parenthesis, our President also very much on the ball, I have not the least doubt that this job will be well and truly done.

"Members of The Institution, I ask you to rise and to drink the toast of 'Our Guests,' coupled with the name of Lord Citrine."

The Rt. Hon. Lord Citrine, P.C., K.B.E., Chairman of the British Electricity Authority, in response, said:

"In rising to respond to this toast, I feel in something like the same frame of mind that a member of the Irish Party who took such a prominent part in affairs at Westminster in the early part of this century was in at a certain public meeting. The meeting was held in the Free Trade Hall at Manchester, and the leader of the Party, a very experienced debater and noted platform speaker, had delivered a masterly oration and had worked his audience up to a high pitch of excitement. When he had concluded, the Chairman called upon another member of the Party, I think it was Mr. Tim Louth, who got up and said something like this: 'Mr. Chairman, Ladies and Gentlemen, after that great and eloquent speech from our noble leader I have not the heart to inflict myself upon you.' He then did what no other politician before or since has done at a public meeting; he shut up and sat down. I can assure you that I feel very much like that. I prefer to sit at these functions as an interested listener in the knowledge that I shall not have acute indigestion as a consequence of having to make a speech! But, of course, as the bad baronet says in *Ruddigore*, 'Duty, duty must be done,' and as our President is firm in his injunction, I must respond to this toast.

"Let me say right away on behalf of the guests that we are all very appreciative of the warm-hearted hospitality of The Institution of Electrical Engineers in inviting us here, and I am sure that every one of us will wish to pay our tribute to Mr. Bishop for the very kindly and generous way in which he proposed this toast.

"I said that I should prefer to sit as an interested listener, and I am sure you must have enjoyed as much as I have the speech given us by our principal guest, Sir Raymond Evershed. It is a great thing to have such a mastery of language as he has displayed. A long experience and study of speakers, always I hope in a humble and student frame of mind, have convinced me at all events that it is not so easy to secure such facility of expression as he has shown to-night. It requires a good deal of hard work and critical self-examination. It is important to be able to say what you really mean to say, and most of you in your different organizations and bodies must many times have wished that you had the faculty of speaking and saying just what you wanted to say. We attach importance to that in the British Electricity Authority, and we are endeavouring as best we can to raise the standard at all the various levels inside the Authority. I am not sure how far we have succeeded, but if I may perhaps be allowed to read you one or two extracts from the minutes of our various Local Advisory Committees, which jointly consist of managerial staff representatives and the employees, it may give you some idea of what I mean.

"Here is one which reads: 'If the causes of recurring accidents were published in the station it would assist in their further recurrence.' Another reads: 'This accident appeared to have been purely accidental.' There is another one which might have a very sinister meaning: 'It was agreed this matter be referred to the Safety and Welfare Sub-Committee'—it concerned Christmas dinner arrangements for the staff! Finally, one of the committees discussing accidents recorded: 'To help to avoid traffic accidents it was proposed that a mirror be erected at the gate approaching the station. The Superintendent promised to look into this.' I do not want you to think that they are inventions of mine and if any of you doubting Thomases care to come to the B.E.A. I will show you the actual minutes!

"For my own part I have been struggling with language for a long time; when I left the Trades Union Congress to go to the National Coal Board the staff thought so little of my English, as a consequence of my having dictated letters and made speeches, that they presented me with a dictionary. To rub it in properly they presented me with twelve volumes and a supplement, so that they could not have thought much of me!

"Our guests vary a great deal, as you perceive from the

Lord Citrine replying to the toast of "Our Guests"

list and as you heard from Mr. Bishop, but I did not hear any reference to the presence of any bankers. I am sorry about that because I feel sure they would have enjoyed themselves this evening! I only know that the announcement this morning and the raising of the bank-rate have almost completely destroyed any element of enjoyment which my colleague Sir Henry Self has in these proceedings. I am sorry that the Ministers have gone because I should have liked to remark on the inconsistency shown in the treatment of this problem of endeavouring to curtail unnecessary commercial and industrial activity. The British Electricity Authority is a public body and it has to have its capital investment programme approved by the Government. That is regularly done year by year. So our programme is regarded as absolutely imperative in the eyes of the Government in the interests of the country as a whole. The raising of the bank-rate will mean in substance that the British Electricity Authority will pay about £1½ million, perhaps £2 million, to the banks for doing the same amount of work. I am hanged if I can see how that furthers the doctrine of greater production meriting greater reward!

"I am also sure that many of my friends in the manufacturing world will share my misgivings on that point. But joking apart, I think that one must pay tribute to the courage of the Chancellor of the Exchequer at a very difficult time from the party political point of view in taking such a stand as he has done in the interests of the country as a whole. As I have said our guests have very varied interests, but I am sure that there is one overriding interest that conditions all of them and that is interest in the prosperity of our country. Whatever may be our divergence of view on all types of subjects, on one thing surely we are united and that is to try in our various ways not merely to maintain the measure of prosperity which our country has attained, but to ensure its expansion within all reasonable limits.

"Those of you who care to look at the trade returns and occasionally read the economic bulletins of the Government must have some misgivings, at all events for the immediate, if not the distant, future. By one means or another Governments have discovered, so far as measures within their own control are concerned, how to maintain full employment, and this has become part of our British democratic way of life and has largely conditioned the infinitely better standards that the mass of our people now enjoy. But Governments do not control all the factors that bear upon this problem, and I can only hope that in the difficult times that quite clearly lie ahead, this country will exhibit that unity which has been so characteristic in days of adversity.

"Lying at the base of British prosperity is the prosperity and activity of the electricity industry. I do not like to repeat to the point of it becoming tiresome, that our country is inferior in the way of electrical horsepower compared with our greatest competitor, the United States. Nor do I wish to make comparisons of the amounts being spent by other countries in trying to make up leeway in their industrial development resulting from the war. But I am personally gratified, and I am sure that most of you are gratified also, by the very clear recognition in the White Paper on nuclear power of the importance of this industry of ours. I only hope that it will not be necessary year by year to convince somewhat sceptical Treasury officials about the importance of carrying that programme through, costly as it is in capital investment. I am sure that what is stated in that White Paper is a quite sober and clear assessment of electrical probabilities, and I hope that we shall not have the unpleasant experience, that has not been absent from our affairs in the last few years, of having annually to demonstrate the necessity of electrical development.

"This is a very friendly industry. It is a very co-operative industry, and I am proud to think that it is probably the only industry, not only in this country but in the world, which provides a forum for every one of us in the form of the British Electrical Power Convention. I am proud to think that I took some small part in the pioneering of that organization.

"The Institution of Electrical Engineers embraces all of us. Every one of our interests is represented, and may I make this confession. When I was a young electrician I used to devour the *Electrical Review*, which was always handed on to me by someone else. I could not afford to pay for it! It seemed to me that it must be the acme of any young man's desire to become closely connected with The Institution of Electrical Engineers and the high standards which that Institution had established. I am proud to be even a Companion Member of The Institution—and thankful that in your charity you took me in at a time which might have been rather difficult for me. I mean the early days when the supply industry was nationalized. The President is a colleague of mine. He is a close colleague, and God knows what I should do without him and Sir Henry Self! Sir John Hacking was a great stalwart for six years, and I know that Jack Eccles, as we call him, is proving and will prove equally steadfast in the problems which we have to face.

"I apologize to you for the inadequate nature of my response to this toast, but I should like to express on behalf of all of us our very sincere thanks for your kind invitation to be present this evening."

The Measurements Section discuss ELECTRONIC INSTRUMENTS

On the 30th November, 1954, Mr. Denis Taylor, M.Sc., Ph.D., Member, opened a discussion on "The Servicing of Electronic Measuring Instruments and its Effect on their Design" at a meeting of the Measurements Section. His remarks, and the discussion, are summarized below.

DR. TAYLOR began by saying that the standard types of laboratory electronic instrument in use in the Atomic Energy Project, e.g. scalers, counting-rate meters, amplifiers, stabilized power supplies, etc., have fault rates of about 0·5–1·5 faults per year according to type. Thus, for simple assemblies comprising two or three standard units, the total fault rate may be sufficiently small to be of little consequence. However, for elaborate assemblies involving many standard units, the operating time per instrument failure may be seriously short. This is particularly so when apparatus is in use for the investigation of some phenomenon which takes place very infrequently. Of course, any failures in the operation of plant instruments (e.g. instruments associated with nuclear reactors or radio-chemical plants in the Atomic Energy Project) are liable to result in a hazard as well as loss of valuable operating time.

Experience of the servicing of electronic instruments by the United Kingdom Atomic Energy Authority is that the real problem remains one of design. However, good designs are possible only with good components, and at the present time many of the components which the instrument designer must use fall far short of the performance required. Progress is being continually made, but even with the specialized nuclear instruments the failure rates are highest for the more orthodox components, e.g. thermionic valves and resistors. In fact, the experience at the A.E.R.E. of the reliability of nuclear instruments is probably typical of the performance obtainable from electronic instruments of a less specialized type, but information on this point is lacking.

In the U.K.A.E.A.'s factories and establishments all faults arising with electronic apparatus are logged and a complete analysis is made of them every twelve months; the information is then made available to the design groups in the Authority and the manufacturers concerned. According to recent reviews, thermionic valves accounted for 70% of all failures, with rectifier tubes the worst offenders; for this reason much use is made at the A.E.R.E. of selenium rectifiers. According to the latest statistics, failure rates for such rectifiers amounted to only 0·4% per annum, compared with 6% per annum for rectifier tubes. A few years ago the failure rate of Vesconol and Nitrogol capacitors was disappointingly high, but in the past year failure rates have been a small fraction of 1% per annum, which is very satisfactory. The position is not so satisfactory with resistors. High-stability resistors still show high failure rates, figures as high as 0·7% per annum being typical. On the other hand, the figures quoted recently by the Atomic Energy of Canada, Ltd., for similar resistors of American manufacture in use in similar nuclear apparatus are of the order of 0·02% per annum. It is perhaps of interest to note that designers of electronic apparatus in the Canadian project derate all their resistors by 50%.

Not all the nuclear instruments in use have the performance quoted above (0·5–1·5 failures per annum). Some instruments of equivalent complexity have a much higher failure rate. A part of the trouble has been that instrument designers are still prone to allow inadequate ventilation in their designs. In general, it has been found possible to find a satisfactory reason for any high or low incidence of failure, and usually these reasons involve the adequacy or inadequacy of heat removal from the heat-generating components.

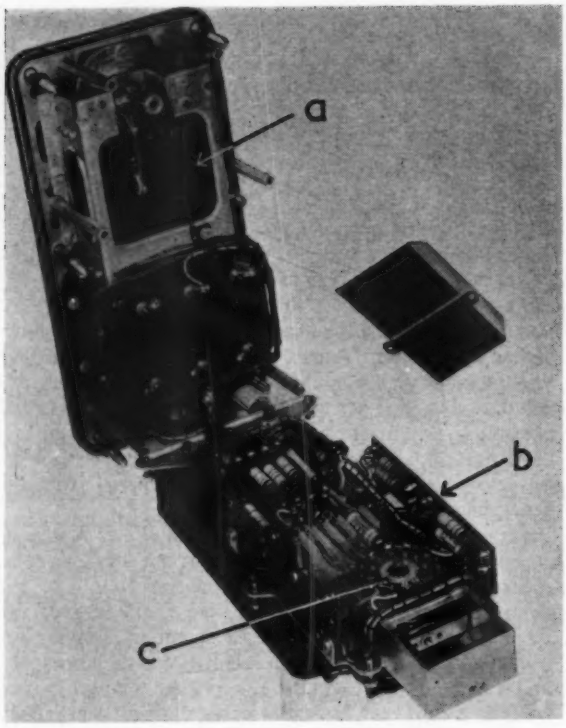
Servicing of electronic equipment in the U.K.A.E.A. is carried out in two stages. Certain servicing personnel are responsible for routine inspection of the complete instruments and first-line maintenance, but repair work involving the replacement of components is carried out away from the plant room or laboratory, and it is the duty of the visiting servicing engineer in such cases to localize the fault to a particular unit and replace this unit. The repair of the faulty unit is then undertaken in the repair shop by industrial labour, using so far as possible standard test rigs. It would be interesting to know whether this method is used in industry generally.

Most of the laboratory instruments now being designed at the A.E.R.E. are provided with self-testing facilities. This reduces the servicing problem at the expense of some complication in the instrument, but generally it has been found worth while. More recently, with the more elaborate instruments the Authority has provided marginal testing facilities. The principle of marginal testing, where the equipment is subjected to changes in currents and voltages that narrow the margin of safety, should prevent the failure of equipment due to slow drifts in their characteristics. Dr. Taylor felt that it would be interesting to have comments from instrument designers and users about the value of marginal testing as a preventive maintenance measure.

He commented that the United States Bureau of Standards had recently published* details of a prediction test unit designed to identify whether certain units or components have deteriorated below safe levels and have become prospective causes of equipment failure, and he wondered whether this was a piece of test gear which all our servicing engineers should have.

Finally, when designing electronic instruments for use in the future, it is obvious that components of high nuisance value must be avoided. Cold-cathode tubes have been much used at the A.E.R.E. and have shown good reliability, and have replaced hot-cathode valves

* "Prediction of Electronic Failures," *The Electrical Journal*, 1954, 153, p. 717.



Portable energy meter, showing how the chassis opens out to allow easy access

Sub-units (*a*) and (*c*) can be unscrewed; and sub-unit (*b*) folds through a right angle.

for some applications. Some experience has been gained with transistors, but it is too early to say whether this component will solve more problems than it makes.

The requirements of the Services, the atomic energy establishments and of industry generally were reflected in the discussion which followed Dr. Taylor's remarks, and the need for greater reliability in electronic measuring equipment was related, not only to the problems of adequate servicing by the personnel available, but also to the growth and complexity of measuring equipment—and under this heading some speakers grouped both radar equipment and computers. Failures in complex equipment, or where continuity of processes is involved, can be most expensive in time and money.

Modern trends in methods of servicing, with special reference to the Services, were reviewed. It was accepted that readily made performance checks *in situ* are desirable and that faulty units should be easily renewable, faults involving replacement of components being, where possible, carried out by specialist personnel in a workshop fitted with the necessary test gear and dummy loads. The transport of repaired units might be a problem, however, and in certain instances the use of expendable sub-units might thus be justified. Another solution is to install units in pairs with provision for change-over when one failed. The scale of spares to be carried and their storage frequently raises problems.

There were many advocates of layouts which would permit easy servicing, and the photograph shows one such design which was discussed.

Among means to assist proper maintenance, importance was attached to the availability of instruction manuals and of such aids as monitoring points on instruments, marked to show the correct meter reading or waveform to be expected at that point. It is also important for the layout of equipment to be clearly related to that of the relevant drawing.

The reliability of components received close attention, and some speakers reported improvement in valve reliability over the past few years; the use of specially selected long-life valves is also growing. The increased application of semi-conductors is a further possibility. It was suggested that valve-holders might receive more attention, and some resistors, especially those of the high-stability and wire-wound types, were reputed to have unduly high failure rates. Capacitors, unless electrolytic, are normally satisfactory, and the relative merits of valve rectifiers and selenium rectifiers appear to depend upon circumstances. Plugs and sockets give good results if carefully designed.

Tribute was paid to the value of consultation with those responsible for maintenance before the design of instruments was settled. Notwithstanding the difficulties of analysis and interpretation, great value could accrue from the existing systems of fault reporting and of return of faulty components adopted in large organizations. It was recognized that components having a finite life must be reasonably accessible. Several speakers described arrangements of sub-chassis and plug-in units designed to afford accessibility and ready replacement. Miniaturization might be a pitfall, particularly as ventilation is of paramount importance; if forced cooling is adopted, filtering becomes a problem. Simplicity of design with adequate spacing between components and a measure of derating in the selection of components were advocated; and it was pointed out that simplification and standardization of both components and units can lead to economy, although long-term stability of response is a problem where recalibration must be infrequent.

Attention was drawn to tests intended to reduce the likelihood of catastrophic faults. The use of a short life-test before instruments were put into service was favoured by some, and the application of marginal tests merited exploration. Some speakers were doubtful whether an overall advantage could be shown in the use of built-in test gear, since this itself required servicing.

In spite of the need for further improvement in reliability, particularly in the more complex equipment, much progress has already been made in the design and production of electronic instruments. The view was expressed that the order of reliability was, in fact, higher than that obtaining in certain associated mechanical devices used in industrial processes.

DIGESTS of Papers in the Proceedings

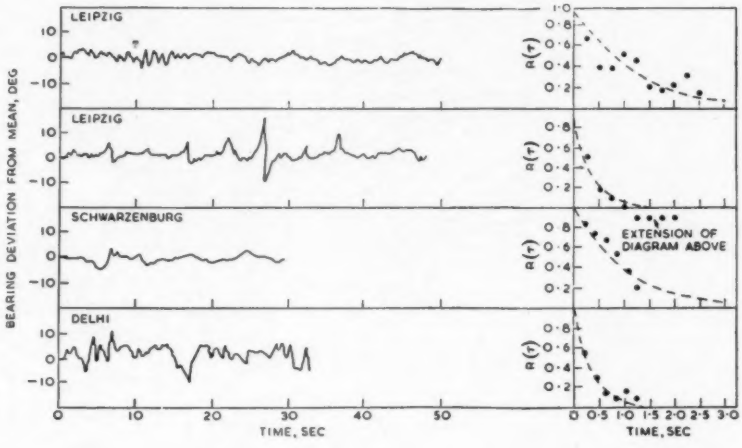
Bearing Fluctuations at High Frequencies

A DIGEST OF A RADIO SECTION PAPER (No. 1715) ENTITLED "ON THE RAPIDITY OF FLUCTUATIONS IN CONTINUOUS-WAVE RADIO BEARINGS AT HIGH FREQUENCIES," BY W. C. BAIN, M.A., B.SC., PH.D. THE FULL PAPER WAS PUBLISHED SEPARATELY IN OCTOBER, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

IN HIGH-FREQUENCY DIRECTION-FINDING with an Adcock system the observed bearing of a remote station is often found to vary appreciably within a second; such fluctuations are due to interference between rays which have travelled from the transmitter by different paths. The accuracy with which the bearing of a station is known will be increased by time-averaging, and the extent of the improvement thus obtained can be calculated only from information about the rapidity of the fluctuations.

The screen of a cathode-ray direction-finder was therefore photographed five times per second while certain h.f. broadcast stations were being received. Typical groups of bearing observations secured in this way are shown in Fig. 1, together with their auto-correlation functions, which give a useful indication of the rapidity of the variations. To aid in the analysis a curve of the type $R(\tau) = \exp(-\tau/\tau_0)$ has been fitted to the observed values for auto-correlation at time intervals τ.

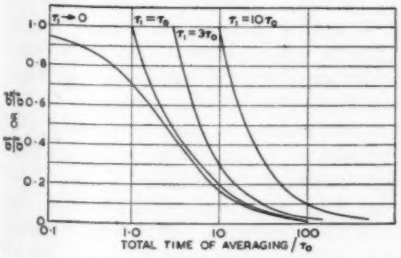
The values of τ_0 obtained from all the results have a mean of 0·75 sec with a standard deviation of 0·51 sec; but among those groups of observations having a bearing variance of over 2 deg², the mean value of τ_0 is 0·56 sec. The reduction in the variance, σ_N^2, of the mean of N consecutive bearings spaced by a time interval of τ_1 sec is shown in Fig. 2, σ^2 being the variance of one observation. For instance, the variance of large bearing fluctuations can be reduced by a factor of ten in 12 sec, provided that the time interval between observations is kept below τ_0 (0·56 sec here). Hence the effect of rapid fluctuations upon the accuracy of direction-finding can be made negligible by averaging over a period of time of less than one minute.



1 *Bearing plots and corresponding auto-correlation functions,* $R(\tau)$

• • • Deduced from observations.
— — — Theoretical curve $\varepsilon^{-\tau/\tau_0}$.

The values of τ_0 deduced from the above plots are (reading from top to bottom of the Figure) 1·15, 0·30, 0·99 and 0·33 sec.

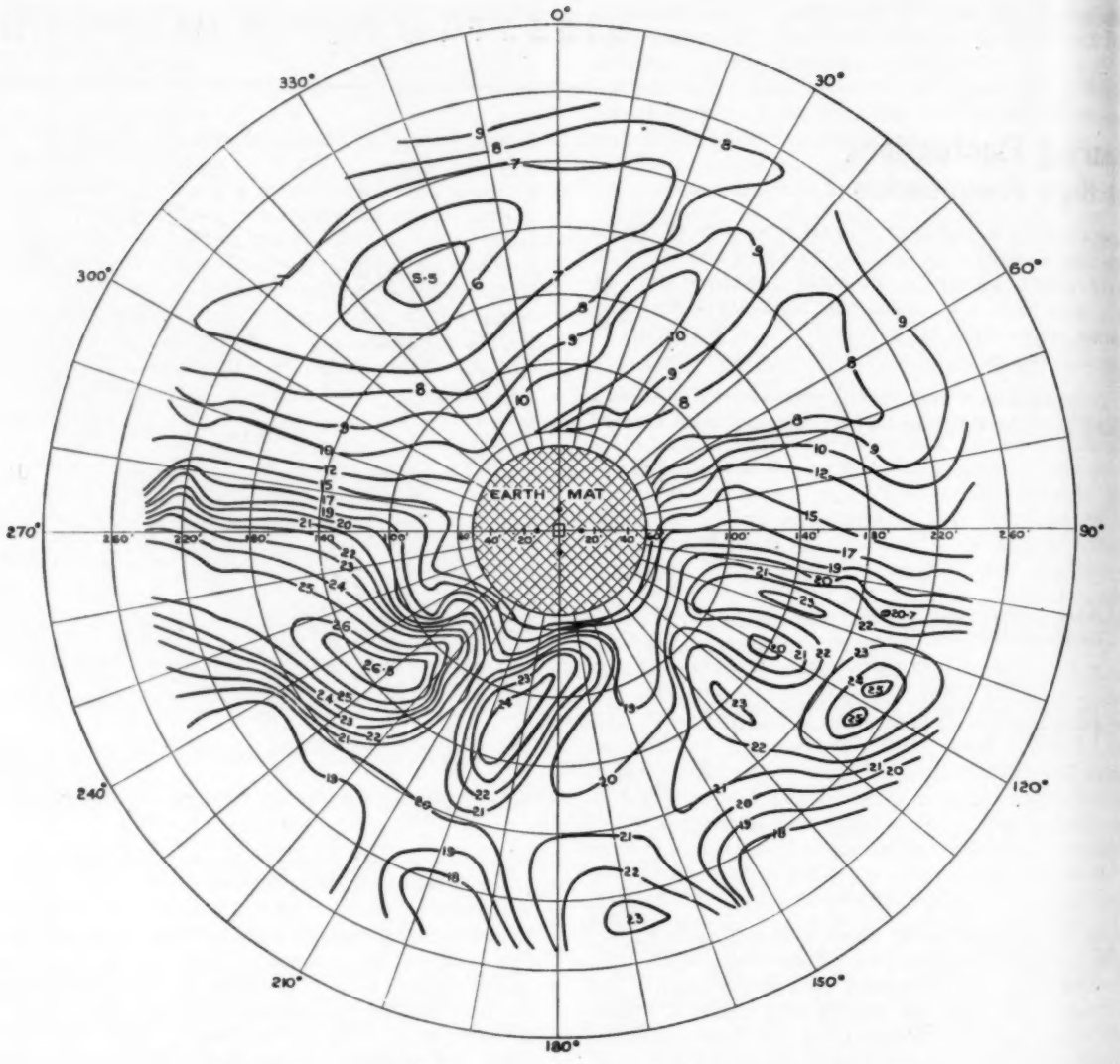


2 *Reduction of variance by time-averaging*

Errors in U-Adcock Direction-Finders

A DIGEST OF A RADIO SECTION PAPER (No. 1810) ENTITLED "SOURCES OF ERROR IN U-ADCOCK HIGH-FREQUENCY DIRECTION-FINDING," BY K. C. BOWEN, B.A. THE FULL PAPER WAS PUBLISHED SEPARATELY IN FEBRUARY, 1955, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

SATISFACTORY METHODS of classifying bearing data obtained by high-frequency direction-finders, and of using



1 *Earth resistivity in kilohm-centimetres at a depth of 5ft for one particular site*

the data to obtain position fixes, depend on a knowledge of the physical causes of bearing errors and on their statistical behaviour. The statistics used to define the errors expected should be obtained from check bearing programmes which simulate, as closely as possible, the normal task of the direction-finder.

Different correlations are observed between bearings of the same transmitter at different times, at different points in space over an area of a few square miles and on different working radio frequencies. This is important in deciding the optimum method of using data gathered over a period. It also enables a statistical analysis to be carried out to estimate the variances of error due to different causes. The method does not produce results of a high order of accuracy, but it is sufficient to indicate the source of any large errors.

Results are in general agreement with previously published figures, except for the variance of uncorrelated errors which cannot be wholly attributed to wave interference. Further investigation has shown that a major contribution arises from observational errors.

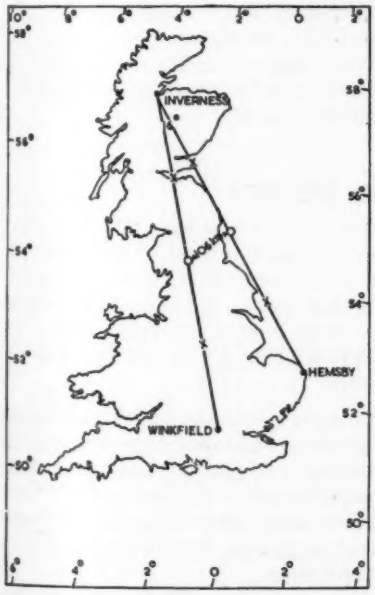
An additional contribution comes from sites over which the rate of change of resistivity is appreciable. A study has been made of an idealized form of the resistivity contours (Fig. 1) of one particular site, and bearing errors have been estimated. They would appear to be of the same order of magnitude as those due to wave interference.

Short-Wave Transmission

A DIGEST OF A RADIO SECTION PAPER (No. 1716) ENTITLED "SOME COMPARATIVE DIRECTIONAL MEASUREMENTS ON SHORT RADIO WAVES OVER DIFFERENT TRANSMISSION PATHS," BY E. N. BRAMLEY, M.SC. THE FULL PAPER WAS PUBLISHED SEPARATELY IN SEPTEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

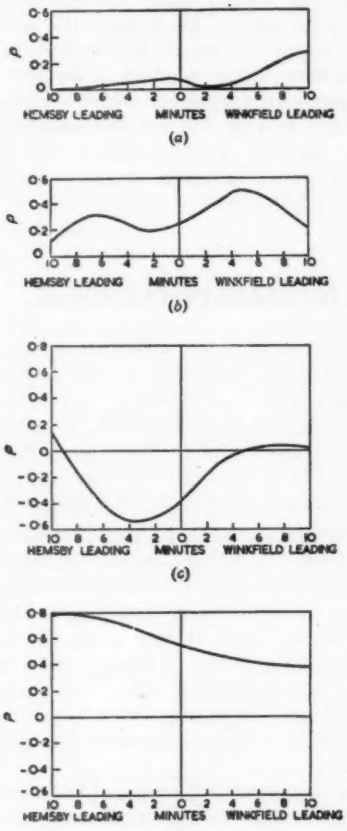
IN RECENT YEARS an extensive series of observations has been carried out on the direction of arrival of short radio waves reflected at the ionosphere. This work, which has been conducted using pulse-modulated transmissions at vertical and oblique incidence, has provided data on the limiting accuracy of high-frequency direction-finding, on first-order reflections, set by ionospheric irregularities. It has been shown that slow changes in the direction of arrival occur, with periods of the order of 20 min, and these are attributable to tilts of the surfaces of constant ionization density in the ionosphere. Some experimental results have been obtained, using spaced receivers or transmitters, which indicate the lateral scale of magnitude of these tilts. The slow changes are accompanied by more rapid fluctuations, due to wave interference within the ray and having periods of the order of a few seconds.

The present experiments were designed to provide further information on the lateral extent of the tilts, by studying the effects occurring simultaneously at two reflection points 106 km apart. This was achieved by the use of two direction-finders, situated at Winkfield and Hemsby, as shown in Fig. 1, working on transmissions from Inverness. Frequencies in the range 5–8 Mc/s were used. The correspondence between the tilts at the two reflection points was studied by calculating the correlation coefficient between the slow components of the bearing fluctuations on the first-order echoes. This was done for a number of hourly periods of observation, and for each period the coefficient was computed for zero time displacement of the results and also for relative time shifts of up to 10 min each way. Some examples of the resulting cross-correlograms are shown in Fig. 2, which



1 *Plan of transmission paths*

× Second-order ionospheric reflection.
○ Second-order ground reflection and first-order ionospheric reflection.



2 *Correlograms for 1F bearings at Winkfield and Hemsby*

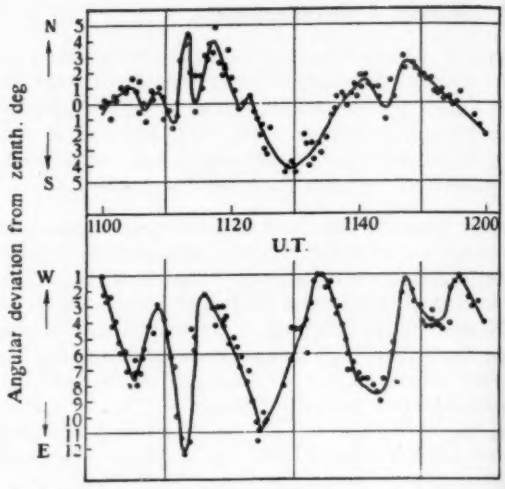
(*a*) 1030–1145 U.T., 21st October, 1952; 7·74 Mc/s.
(*b*) 1335–1500 U.T., 23rd October, 1952; 7·74 Mc/s.
(*c*) 1550–1655 U.T., 3rd March, 1953; 6·58 Mc/s.
(*d*) 1635–1810 U.T., 12th November, 1952; 5·58 Mc/s.

illustrates the diverse nature of the results. On the average, for zero time shift there was a negative but negligibly small correlation which rose to positive values with increasing displacements either way. This is due to the tendency for the occurrence of bearing variations having periods of the order of 20 min.

An interesting feature disclosed by the results was a diurnal variation of the east–west tilt in the F-layer.

Over the period 1000–1600 U.T. the bearings tended to swing gradually towards the west at a rate consistent with the tilt changing at a rate of 0·2° per hour.

The second object of the experiments was to compare the directional fluctuations occurring on the second-order (2F) reflections on the two paths. These trajectories involve a mid-point reflection at the surface of the earth, and, as shown in Fig. 1, one of the mid-points lay on land and the other on the sea. It was found that the land mid-point gave a rather weaker and more scattered 2F echo than the sea, but only a slight (though significant) increase in the variance of the bearing fluctuations. The main variations in the 2F bearings were caused by ionospheric tilts, which produce a variance about ten times as great as on the 1F echo. Thus although the experiments showed that the land behaved as a rougher reflector than the sea, it produced only a small effect on the directional variations in the present case.



1 *Fluctuations in direction of arrival at nearly vertical incidence*

Transmitter: Slough. Date: 13th December, 1949.
Receiver: Theale. First-order F reflection: 4·86 Mc/s.

Fluctuation of Ionosphere-reflected Waves

A DIGEST OF A RADIO SECTION PAPER (No. 1713) ENTITLED "SOME ASPECTS OF THE RAPID DIRECTIONAL FLUCTUATIONS OF SHORT RADIO WAVES REFLECTED AT THE IONOSPHERE," BY E. N. BRAMLEY, M.SC. THE FULL PAPER WAS PUBLISHED SEPARATELY IN AUGUST, 1954, AND IT WILL BE PUBLISHED IN PART B OF THE PROCEEDINGS.

WHEN A HIGH-FREQUENCY RADIO WAVE is received after a single reflection by the ionosphere, it is found to undergo changes in its apparent direction of arrival. These changes can be divided into two types, according to the rates at which they occur. The slower variations in direction have periods of the order of 20 min and are believed to be caused by ionospheric tilts. The more rapid fluctuations have periods of the order of a few seconds, and are associated with the short-period fading of the signal.

Fig. 1 illustrates the two types of directional variation in measurements made at nearly vertical incidence. The rapid fluctuations, which are the subject of Mr. Bramley's paper, are represented by the deviation of the plotted points from the smooth curve which represents the slower changes. A notable feature of the rapid fluctuations is that they are associated with amplitude diversity effects on spaced receiving aerials; this indicates that the downcoming wave must consist of an angular distribution, or cone of waves, as first pointed out by Eckersley.

Measurements of the magnitude of the rapid directional changes show that this is markedly frequency dependent. In the range 3–8 Mc/s the r.m.s. angular deviation is roughly inversely proportional to the square of the frequency, for either E- or F-layer reflections; it has a value of about 0·5° at 5 Mc/s under quiet conditions, but is appreciably increased by ionospheric storms and spread-F effects.

It is suggested that irregularities in the lower part of the E-region, such as are assumed to be responsible for long-distance v.h.f. propagation, may account for the quiet-condition directional results at high frequencies. Mr. Bramley gives a theory of the diffraction of a vertically-incident plane wave by a horizontal layer of such irregularities. He shows that the resulting angular fluctuations observed at the ground would have a magnitude inversely proportional to the square of the frequency, as found experimentally, and the observed results may be used to deduce a value of about 500 m for the scale of the assumed irregularities in ionization density.

Testing Large Stators

A DIGEST OF A SUPPLY SECTION PAPER (No. 1771) ENTITLED "AN EXAMINATION OF HIGH-VOLTAGE D.C. TESTING APPLIED TO LARGE STATOR WINDINGS," BY R. T. RUSHALL AND J. S. SIMONS, B.SC.(ENG.), ASSOCIATE MEMBERS. THE FULL PAPER WAS PUBLISHED SEPARATELY IN JANUARY, 1955, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

THERE IS A GENERALLY FELT NEED among manufacturers and users of large generators and motors for a test which will reliably indicate the condition of stator-coil insulation. Recently much attention has been given, particularly in America, to a non-destructive form of high-voltage d.c. test for this purpose, but the evidence of its effectiveness is unconvincing.

The method involves measurement at successive increments of applied voltage of the steady-state leakage current passing between winding and frame. It is claimed that the test reveals insulation weakness by a significant

bend in the current/voltage curve and that it is possible often to predict ultimate breakdown. The maximum test voltage is decided with due regard to the rated voltage and length of service of the machine, and in general is based upon an assumed d.c./a.c. r.m.s. voltage ratio for equal effectiveness of between 1·5 and 1·7.

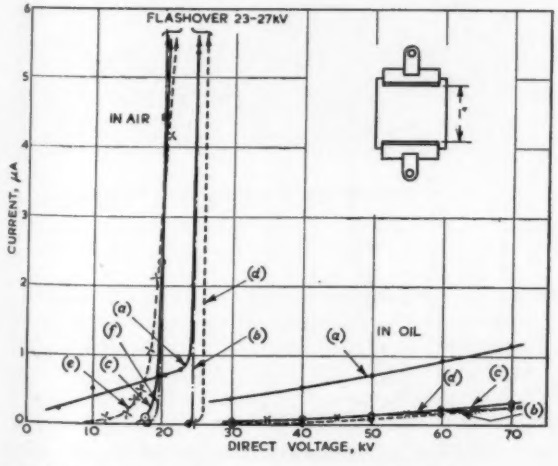
The potentialities of the method are investigated in tests on both h.v. stator coils and on sound and defective specimens of typical sheet insulation.

Defects such as perforations, voids and internal creepage paths, deliberately formed in sheet specimens, produce no perceptible response in the current measurements. Sudden and unpredictable failure at an appreciably reduced voltage is the only real evidence of the weakness.

When the path of failure includes a superficial leakage path, however, a prediction of failure is sometimes possible. Results obtained with a favourable form of specimen are shown in Fig. 1. The abrupt and considerable increase in current which occurs in air, however, is due solely to the onset and development of gaseous discharge, and the failure so predicted is essentially that of the intervening air space.

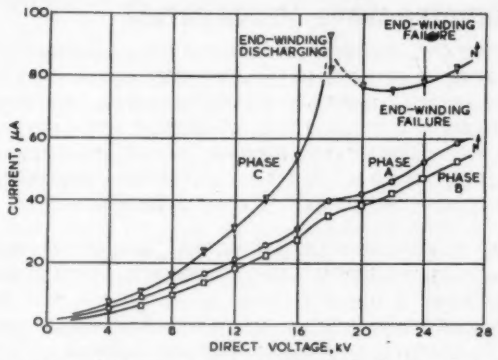
Tests on a complete high-voltage stator winding and on single stator coils give results in agreement with those obtained on the sheet specimens. Unpredictable failure is prone to occur in the end-windings, as indicated in Fig. 2. No assessment of the more vital slot-insulation quality is possible, either from these or other recorded results.

Surface leakage and discharge emanating from the end-winding can have a predominating influence, and any apparent prediction of failure obtained is invariably the result of these effects. This is demonstrated by measurements made on a stator coil, which are plotted in Fig. 3. Extraneous corona which may originate at



1 *Surface-leakage test results on sheet insulations*

(*a*) Paper.
(*b*) Micafolium.
(*c*) Black-varnished cloth.
(*d*) Clear mica.
(*e*) Dark brown mica.
(*f*) Air.

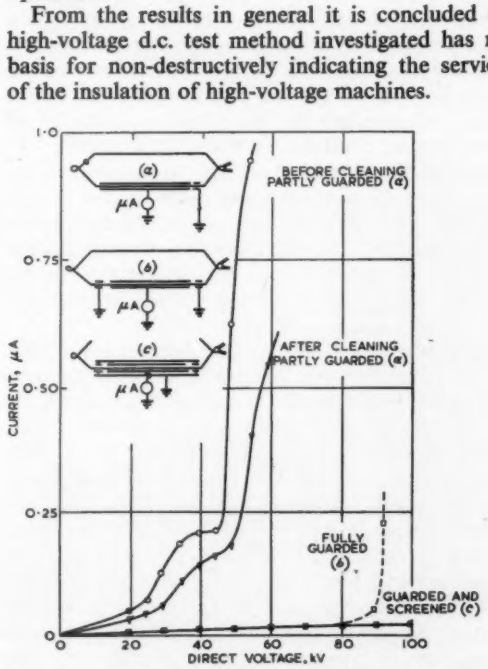


2 *Current/voltage curves of individual phases of an 11kV stator winding*

the connections and test leads, can also produce misleading evidence.

In comparison with the current involved in the surface-leakage phenomenon, the current associated with a quite serious local defect in the slot insulation may well be insignificant and the defect remain undetected except by failure. Moreover, the stress distribution over the end-windings is different under d.c. than under the practical a.c. conditions, being more searching in the former case; consequently, any genuine indication of end-winding weakness may be irrelevant to service operation.

From the results in general it is concluded that the high-voltage d.c. test method investigated has no valid basis for non-destructively indicating the serviceability of the insulation of high-voltage machines.



3 *Current/voltage curves obtained on an 11kV stator coil, showing end-winding leakage before and after cleaning and the effect of guarding*

Millimetre-wave Propagation

A DIGEST OF A RADIO SECTION PAPER (No. 1761) ENTITLED "EXPERIMENTAL EQUIPMENT AND TECHNIQUES FOR A STUDY OF MILLIMETRE-WAVE PROPAGATION," BY W. E. WILLSHAW, M.B.E., M.SC.TECH., MEMBER, H. R. L. LAMONT, M.A., PH.D., ASSOCIATE MEMBER, AND E. M. HICKIN, ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

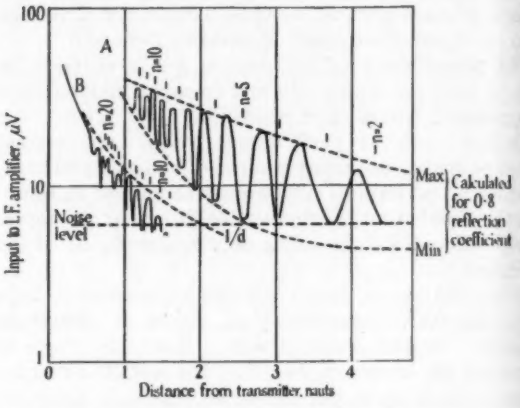
TO THE MANY KNOWN COMPLICATIONS that beset the path of radio waves through the atmosphere, another was added when it was discovered by Van Vleck that the oxygen molecule shows a resonance effect which gives rise to absorption of electromagnetic radiation. Van Vleck's prediction was made on theoretical grounds, and showed that the absorption arose from the permanent-magnetic moment associated with the oxygen molecule; fortunately the effect is limited to a number of discrete wavelength regions, of which the longest is in the neighbourhood of 5 mm. By the time this paper appeared the effect had been demonstrated in the laboratory by Beringer, who used a length of waveguide filled with pure oxygen and mixtures of oxygen and nitrogen, and measured directly the attenuation thus produced. From this work it appeared that for frequencies at the peak of the absorption curve the attenuation of a radio wave in the atmosphere would be of the order of 14 dB/km.

It was in the light of this information, as yet unpublished, that the programme of work described in the present paper was initiated in 1945, in order to assess under practical (as opposed to laboratory) conditions the effects produced on communication systems at wavelengths of a few millimetres. The work was carried out by a team of people, and the authors have set out to summarize and correlate the contributions made by all in order to present a coherent account of the work.

At this time the shortest wavelength at which extensive work has been done was in the neighbourhood of 12 mm, and therefore it was necessary to evolve methods of power generation and detection and to develop circuit technique and methods of measurement for frequencies in the 60 000 Mc/s region, for which the waveguide was only 4·5 mm × 2 mm in cross-section.

In accordance with what has now become established practice for extending the frontier of frequency, power was first generated in crystal distorters from which the very useful power of 200 μW could be extracted at a wavelength of 6 mm. These were followed by specially designed magnetrons, of both pulse and c.w. types, giving a few watts output. Crystal rectifiers built into tiny cavities were used for detection and frequency mixing, and measurements of power were made both by water calorimeters and thermistors. Measurements of frequency made use of high-Q-factor cavities of calculated size, the absorption lines in ammonia being used at a later stage to provide calibration checks, with very close agreement. In order to attain the highest mechanical accuracy in the measurement of reflections, a standing-wave indicator using a curved waveguide was evolved.

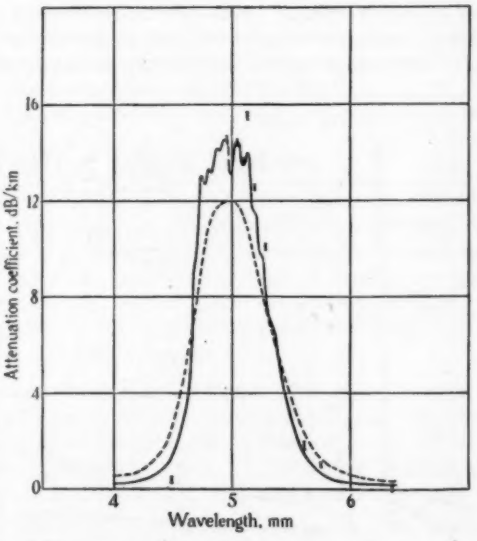
As the basic techniques became available attention was turned to the building of equipment for propagation trials. A low-power transmitter, using second-harmonic



1 *Signal-strength/distance curves for millimetre-wave transmission over sea*

A. 6·35 mm wavelength.
B. 5·31 mm wavelength.
Transmitter height: 15 ft.
Receiver height: 63 ft.

generation, with an output of a few tens of microwatts was used for the first propagation trials in 1946, together with a superheterodyne receiver. These trials took place over sea, with the transmitter on land and the receiver mounted at a height of 60 ft on a gyro-stabilized platform



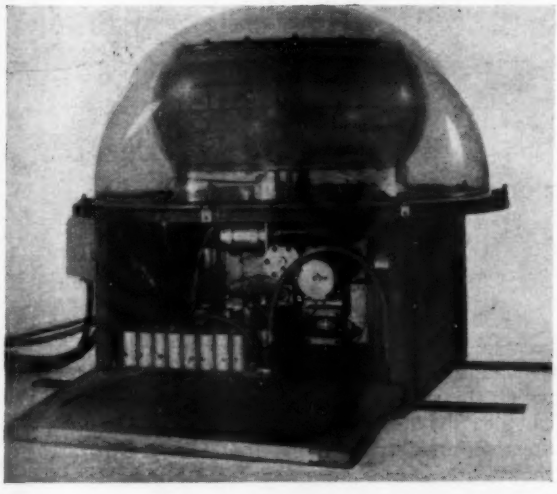
2 *Theoretical and measured attenuation due to absorption by atmospheric oxygen*

Theoretical curves.
——— $\Delta\nu/c = 0{\cdot}02\ \text{cm}^{-1}$.
- - - - $\Delta\nu/c = 0{\cdot}05\ \text{cm}^{-1}$.

on board ship. Although the aerial mirrors were only 16 in in diameter, the gain of each was some 40 dB with a beam width of 1°, so that no little care was needed to maintain aerial alignment, even with the stabilized platform. Fig. 1 shows some of the results obtained in these trials, from which two properties will be immediately clear. These are the high level of the reflection coefficient of the sea-reflected wave for a wavelength of 6·35 mm (a maximum value of 0·8 being obtained for a rippled sea surface) and the increased attenuation for the wavelength of 5·3 mm, which is just within the region where oxygen absorption occurs.

In later trials over land, with essentially the same equipment, an experimental curve relating to absorption in the atmosphere to wavelength was obtained. This is reproduced in Fig. 2, and its simple form, based on a very limited number of averaged points, gives no clue to the amount of labour involved in producing it, nearly 1 000 measurements being made with a mobile receiver at many points over a path of up to 1½ miles on an aerodrome site.

Finally, trials were made, again over sea, of a communication link using a high-power transmitter and omnidirectional superheterodyne receiver (Fig. 3) with



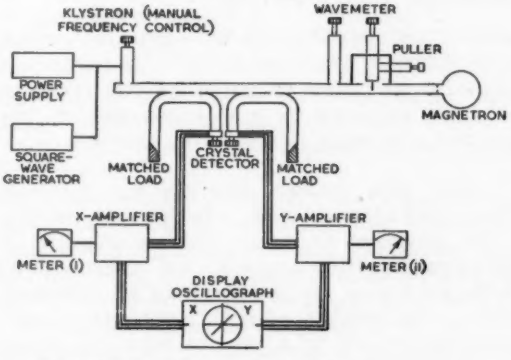
3 *Omnidirectional superheterodyne receiver*

variable recurrence rate speech modulation. A number of wavelengths within the absorption band covered by the curve shown in Fig. 2 were used, with corresponding variation in communication range. At a wavelength of 5·7 mm, where the atmospheric absorption is 10 dB/km, satisfactory speech was transmitted with a directional aerial at the transmitter and an omnidirectional aerial at receiver over a communication range of 4·5 km, this being increased to 13 km when a directional aerial was used at the receiver.

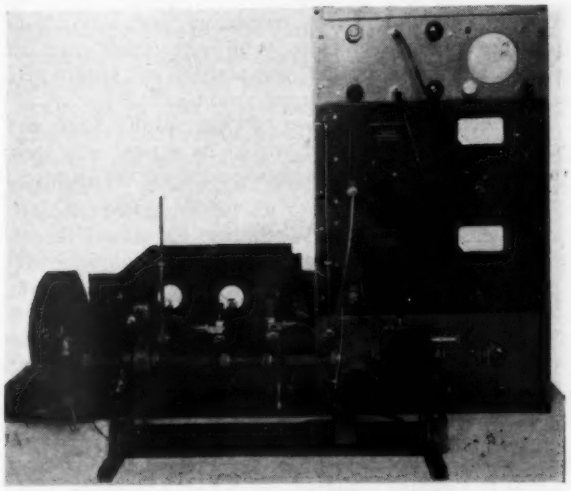
Magnetron Pulling Figure

A DIGEST OF A RADIO SECTION PAPER (No. 1992) ENTITLED "COLD MEASUREMENTS OF 8-MM MAGNETRON FREQUENCY AND PULLING FIGURE," BY A. E. BARRINGTON, PH.D., B.SC., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN MARCH, 1955, IN PART B OF THE PROCEEDINGS.

MAGNETRON PULLING FIGURE is usually defined as the sum of the maximum frequency excursions due to changes of position of a reflecting discontinuity, giving a 1·5 : 1 standing wave ratio. Its value is determined by the coupling of the magnetron into its waveguide, and has been found to be a difficult quantity to control. The coupling coefficient cannot be altered once the valve is completed, and therefore it is desirable to determine the pulling figure prior to final assembly by measuring the reflection of the cold block on the ends of a waveguide with a variable-frequency local oscillator.



1 *Eight-millimetre resonance display*



2 *Equipment for determining pulling figure*

Existing methods are either too lengthy, or—owing to the small Q-values of 8 mm magnetrons and variations of local-oscillator output with frequency—not sufficiently accurate.

A method has been devised by the author to overcome these limitations (Figs. 1 and 2). Periodic signals, A and B, proportional to outgoing and reflected power, are applied to the X- and Y-plates of a cathode-ray oscillograph, resulting in a straight-line trace whose slope, tan B/A, is independent of local-oscillator power. The rate of change of slope with frequency is shown to be a maximum at resonance, and the change of resonant frequency with position of the calibrated puller probe, as measured with an absorption wavemeter, has been found to agree very closely with the pulling figure of oscillating valves.

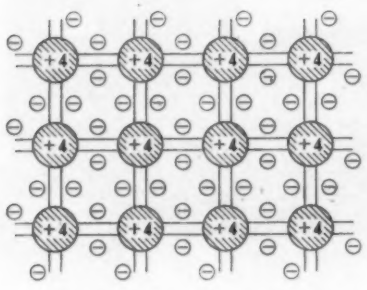
Transistor Electronics

A DIGEST OF A STUDENTS' PAPER WITH THE ABOVE TITLE, BY W. D. JACKSON, B.SC., GRADUATE. THE PAPER WAS AWARDED A STUDENTS' PREMIUM BY THE COUNCIL, AND A LONG ABSTRACT OF IT WAS PUBLISHED IN THE STUDENTS' QUARTERLY JOURNAL, DECEMBER, 1954.

SEVEN YEARS HAVE ELAPSED since the first successful laboratory transistor was made. In this time, development has progressed to the point where several commercial types of transistor are now available with sufficient stability to be used in place of thermionic valves in a considerable number of circuit applications.

Transistors are one of a class of electronic devices which depend on electron motion within the structure of a semi-conducting material. Semi-conducting properties may be imparted to elements from group IV of the Periodic Table. Hitherto, transistors have been made from germanium, but recently other materials, such as silicon and intermetallic compounds of groups III and V, have been under investigation.

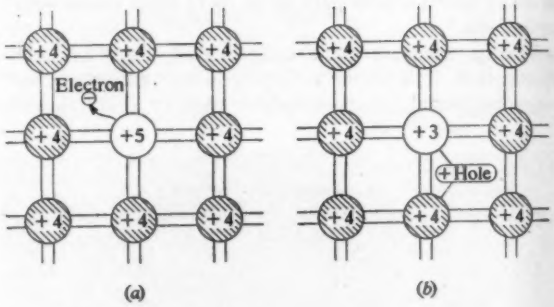
Conduction in a semi-conductor results from the presence of imperfections within its crystal structure, the most important of these being due to either an excess or a deficiency of electrons. While it can readily be seen that an excess of electrons gives rise to conduction, it is not so obvious that electron deficiency can give the same result, and the concept of a "hole" has been devised to aid the understanding of this.



1 *Covalent bonds in perfect germanium*

Fig. 1 shows pure germanium to be a perfect insulator, since all the valence electrons are utilized in the formation of covalent bonds. Chemical impurities may be introduced for the purpose of creating electronic imperfections. A group V element, such as antimony or arsenic, acts as a donor impurity providing one excess electron for each group V atom [Fig. 2(*a*)]. The resultant impure germanium carries a negative charge and is therefore known as *n*-type germanium.

Indium or gallium from group III are acceptor impurities giving rise to one incomplete valence bond for each atomic impurity. These incomplete bonds, being due to a deficiency of electrons, give rise to *p*-type germanium which has a net positive charge. This effect would also result if free positive charges or holes existed within the structure [Fig. 2(*b*)]. Since electron motion can alter the location of an incomplete bond, holes have apparent mobility. However, they are not particles, for they clearly have no mass.



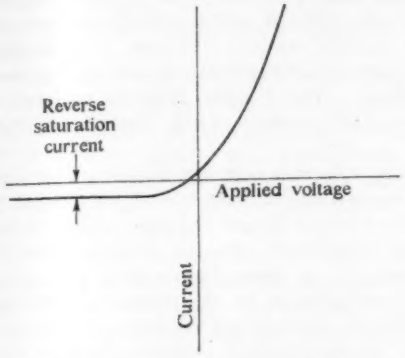
2 *Germanium with impurities*
(*a*) *n*-type with Group V impurity.
(*b*) *p*-type with Group III impurity.

The imperfections considered so far are majority carriers. Thermal and optical effects can generate electrons in *p*-type, and holes in *n*-type, structures, and these electrons and holes are minority carriers and have a short life.

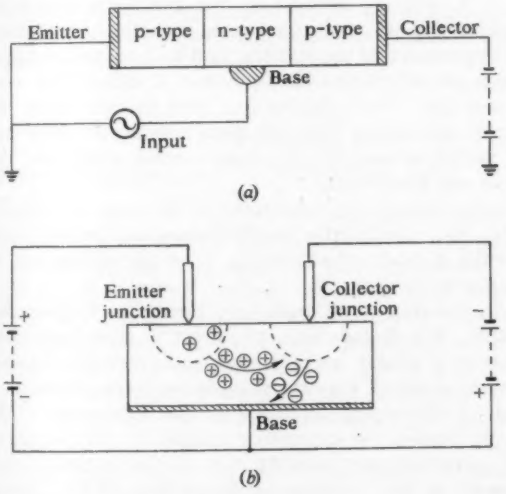
A single crystal may contain both *p*-type and *n*-type regions, the boundary between such regions being a *p–n* junction. With zero externally applied field there is an initial diffusion of majority carriers across the boundary. Since this involves a net transfer of charge, an electrostatic potential "hill" is built up with a polarity such that it prevents further movement of carriers. A reverse bias derived from an externally applied field merely serves to reinforce the potential hill; a small reverse current flows, owing to the minority carriers.

On the other hand, forward bias reduces the potential hill and permits a constant flow of majority carriers across the barrier, which gives a current in the external circuit. The overall rectification characteristic of a *p–n* junction is shown in Fig. 3.

A junction transistor consists of two *p–n* junctions in the back-to-back arrangement shown in Fig. 4(*a*); the sections of germanium are, from left to right, the emitter, the base and the collector. The base–collector junction



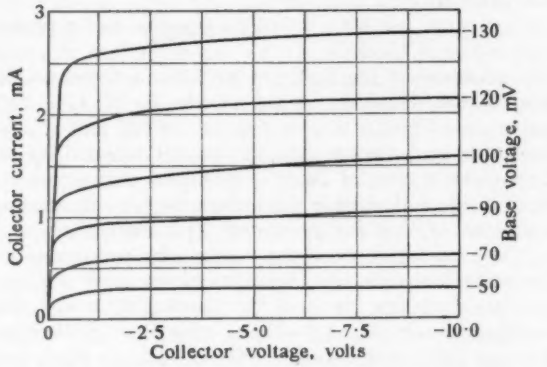
3 *Typical p–n junction rectification characteristics*



4 *Transistors and connections*
(*a*) Junction type. (*b*) Point-contact type.

is given a reverse bias, so that the collector current is small. A forward bias applied to the emitter–base junction enables majority carriers to diffuse from the emitter into the base region. If this region is sufficiently narrow, these carriers can pass through to the collector, where they greatly augment the collector current. Thus the collector current can be controlled by variation of the forward bias on the emitter–base junction. A typical set of collector characteristics is given by Fig. 5.

When a junction transistor is operated with the emitter earthed, the base as the control element and a collector output, there is an obvious similarity to the earthed-cathode triode, the emitter, base and collector corresponding to the cathode, grid and anode respectively.



5 *Collector characteristics with base voltage as parameter, for junction transistor*

The analogy is of limited usefulness, for the transistor has a comparatively low input impedance of the order of 1 000 ohms, owing to the existence of an appreciable base current.

It has long been known that a rectification takes place when the pointed end of a fine wire is brought into contact with a germanium crystal, the contact requiring electroforming for satisfactory operation. A point-contact transistor consists of two such contacts placed a few thousandths of an inch apart on a base of *n*-type germanium, one contact acting as the emitter and the other as the collector. Since forming is considered to produce regions of *p*-type germanium around the points [Fig. 4(*b*)], performance is similar in most respects to that of a junction transistor using the *p–n–p* arrangement. There is the important difference, however, that a current gain can be obtained between the emitter and the collector; at present, the mechanism by which this is achieved is not fully understood.

Both types of transistor can be used as amplifiers and oscillators, inter-stage coupling transformers being required in the former for maximum power gain. The junction units are generally superior in amplifier circuits by virtue of the greater gains obtained, better linearity and lower noise level. The emitter–collector current gain of the point-contact type results in negative resistance characteristics at the base and emitter, and these characteristics can be utilized in simple oscillator and trigger circuits using only one transistor.

The transistor is a compact and robust device giving its full sensitivity with supply powers of a few milliwatts and without heaters. It is, however, sensitive to temperature change, and its performance at high frequencies is restricted by the limited mobility of holes and electrons within a crystal structure.

HOME EVENTS

LONDON

ORDINARY MEETING

The resources of the E.R.A. were fully deployed on the 31st March, 1955, in support of Mr. E. W. Golding's paper on *Electrical Energy from the Wind*, and a large gathering had already had its interest whetted by an impressive display of models, specimens and pictures—both inside and outside the lecture theatre—illustrating man's use of wind energy in many ages and lands.

The President opened the meeting by welcoming an unusually high number of foreign visitors, most of whom had taken active parts in the development of wind-energy projects in the several countries of Western Europe. He paid tribute to Mr. Golding's work and international reputation.

The author himself, in introducing his subject, remarked on the appeal of "something for nothing," but it was soon clear that this was nevertheless to be a sober and responsible occasion. It was also to prove a cosmopolitan one, and Mr. Golding's world-wide review showed that what he referred to as under-developed regions present the most promising field for applying modern technical advances. These advances were not, however, just a matter of apparatus for energy conversion, but they include also the means for its utilization and storage, and Mr. Golding demonstrated his idea of an integrated scheme by the use of an illuminated display panel. He said that for larger-scale plants it becomes correct to contemplate delivering energy directly into an electricity supply network. Mr. Golding stressed the distinction here involved, and concluded by a recognition of the value to his cause of the action of the two major supply undertakings in Great Britain in each ordering a 100 kW experimental machine.

Mr. T. G. N. Haldane opened the discussion. He commended the high technical merit of the E.R.A.'s measurement and survey work, often accomplished in conditions of physical hardship. Progress with the design and building of large machines inspired by the Association had been disappointing, and it was now evident that much more time and money would be needed. The prospects for the medium sizes, mainly abroad, were brighter. All the same, he felt that the future lies with the large fuel-saving plant.

Foreign speakers contributed extensively to the subsequent proceedings, and described developments which had occurred abroad. They were led by Professor D. Dresden (Netherlands), the Chairman of the International Group for Wind Power Studies, and included, in addition, representatives of Denmark, West Germany, France (two speakers) and Eire. Prof. Dresden gave details of the methods employed in the Netherlands for measuring wind characteristics, and pointed out that the first cost of a windmill was largely governed by the maximum gust velocity which it was designed to withstand. Dr. U. Hütter based his contribution on practical experience since 1940 with some 60 German machines ranging up to 50 kW output each. He was of the opinion that the large plant, of, say, 1 000 kW rating, should take the form of a number of the smaller well-tried units ganged together and operated as a group. In this he was supported by others. The French speakers included a representative of the inventor of the "depression" type windmill.

Developments in Britain were centred around the two 100 kW machines which had been built for the North of Scotland Hydro-Electric Board and the B.E.A. respectively. Mr. T. Mensforth gave an artlessly delivered account of the first of these, but quickly gained the admiration of his audience for the pertinacity and skill which he had clearly brought to overcoming a succession of difficulties. He declared his unshaken faith in wind energy, and indicated how the lessons he had learnt should be applied in designing future plants. Mr. W. T. J. Atkins's remarks on the B.E.A. project were gloomy. He said that unexpected objections to the size and appearance of the machine had been raised, and that it had proved impossible to obtain a satisfactory permanent site. Trial running had been carried out at the Prae Wood testing site, but wind conditions there did not permit of any serious experimental work, and the future was problematic.

The views of the meteorologist were put by Dr. R. Frith, who produced a highly interesting periodogram showing a peak of variability of wind velocity at an abscissa of $3\frac{1}{2}$ days.

Mr. Golding could reply only briefly to the long discussion, but found time to direct a good-humoured shaft at a young speaker who had extemporaneously reinvented one of the devices on show in the exhibition.

Mr. L. Drucquer deputized for the Chairman of the Supply Section in expressing thanks to Mr. Golding, and remarked that, among the divided opinions put forward, it was perhaps significant that all the foreign contributors were on the author's side. W. T. J. A.

EXTRA MEETING

A paper on *The Electrical Equipment of the Toronto Subway Cars*, by Frank W. Roberts, was read at an Extra Meeting on March 10th, and because it was not possible for the author to travel from Canada to London, Mr. G. J. Corson and Mr. F. H. Kitchen were nominated to present it on his behalf. Unfortunately Mr. Kitchen was indisposed and it was left to Mr. Corson to read the paper alone.

Usually a traction subject is popular, but on this

occasion the attendance was disappointing. This, however, did not detract from the liveliness of the discussion and the interest taken in the paper, no fewer than twelve speakers taking part in the discussion. The many cogent points raised and the opinions expressed will be of considerable value in The Institution's records on electric traction. In particular, the merits or otherwise of the use of the hypoid-gear transmission with traction motors were vigorously discussed. Altogether the interest shown more than compensated for the small attendance—which, however, included quite a number of the traction giants.

There was a certain amount of criticism on the very considerable quantity of auxiliary equipment underneath the cars—there is so much of this that it was difficult to see from the lantern slide how the air ducts are run to the traction motors. No doubt the congestion is due to the additional auxiliary equipment required for Canadian conditions.

A very good colour film of the Toronto Transit System was shown by Mr. Corson, but it would not be an unfair criticism to say that the length of this, coupled with Mr. Corson's introductory remarks, occupied rather too much time and reduced the time available for discussion.

Since he was only deputizing for the author, Mr. Corson is to be congratulated on his ability in replying to the diverse comments and questions raised by those taking part in the discussion. C. M. C.

MEASUREMENTS SECTION

Magnetic Measurements

The measurement of the properties of magnetic materials has become more difficult as a result of the development of new alloys and as a result of their use on the one hand at very high flux densities and on the other hand—in the case of high-permeability alloys—at very low magnetizing forces. It is not surprising, therefore, that, in spite of the cold weather, there was a good attendance at the Measurements Section meeting on March 1st to hear two papers on the measurement of magnetic properties.

Dr. G. G. Bradshaw expounded the paper by Professor F. Brailsford and himself, entitled *Iron Losses at High Magnetic Flux Densities in Electrical Sheet Steels*. By measuring the temperature rise of the iron directly, with the magnetizing current flowing only for a few seconds, difficulties arising from the heat generated in the magnetizing coil were avoided, and it was possible to determine the losses up to flux densities of 2·4 Wb/m^2. It was found that, when the calculated eddy-current loss was deducted from the total losses, the hysteresis loss, including the anomalous loss, reached a saturation value at high flux densities. The authors suggest an empirical formula by which this loss can be calculated for any material, if the hysteresis loss at a flux density of 1 Wb/m^2 and the saturation intensity of magnetization are known. The experimental work was not claimed to be adequate to establish the validity of this formula, but only to indicate a promising line of approach.

Dr. R. Street outlined the difficulties of measuring small values of magnetizing force, and also the time necessary to adjust the compensating ampere-turns in a precision permeameter to obtain uniform flux density, when he read the paper on *An Improved Precision Permeameter*. He indicated the principal properties of his method using a flux-gate detector, details of which were then given by his co-author, Dr. C. D. Mee. The detector consists of two Permalloy rods, 3 cm × 0·05 cm, mounted side by side with separate primary windings and common secondary and tertiary windings. Current from an audio-frequency supply through the primary windings saturates the rods in opposite directions, so that no e.m.f. is induced in the secondary when there is no external field. However, with an external field, a resultant flux exists for part of the cycle, so producing a secondary e.m.f. This is converted to a direct current, which is fed back to the tertiary winding to produce a balancing field to the external field. The magnitude of this direct current is a measure of the magnetizing force.

Dr. L. G. A. Sims opened the discussion on the paper by Professor Brailsford and Dr. Bradshaw and referred to the difficulty of obtaining precise knowledge of the specific heat of magnetic laminations, the possibility of some heat loss even during a short period, and the lack of evidence of repeatability of the results. He sought information on a number of other points and managed to slip in a few comments on the M.K.S. system of units not altogether in its favour. He was followed by Mr. Martindale who suggested that the anomalous loss might be a frequency-squared component of the hysteresis loss. He discussed at some length the discrepancies in the test results by different methods shown in the paper by Dr. Mee and Dr. Street and wondered whether inhomogeneities due to grain size were a contributory cause of these discrepancies.

Professor J. T. MacGregor-Morris placed the method of test developed by Professor Brailsford and Dr. Bradshaw intermediately between methods of testing large sheets and of testing single crystals. He would have liked a relationship established between the three methods, and also measurements made at temperatures higher than room temperature.

Mr. C. E. Webb welcomed the paper by Dr. Mee and Dr. Street as providing a most useful method at low values of magnetizing force. He then suggested the possibility of alternative explanations of the shape of the hysteresis curves in the other paper, and showed how the extrapolation of the hysteresis-loss curve from low flux densities to higher densities could be carried out more accurately by a modification of the method developed in the paper.

Mr. O. I. Butler stressed the importance of testing magnetic materials either with sinusoidal flux or sinusoidal magnetizing force, pointing out that the hysteresis losses at high flux densities might vary over a range of

2 : 1 with non-sinusoidal waveforms of equal form factor. He advocated the use of thermal wattmeters when used with circumspection.

Mr. E. Rawlinson drew attention to Astbury's work on eddy-current losses, involving the possibility of the true losses differing by as much as 20% from those calculated by the normal formulae. He also dealt in some detail with the possibility of error in the measurement of magnetizing force by the flux-gate.

Mr. D. A. Langford was the last of the speakers on the Chairman's list, and he concerned himself with the possibility of end effects causing error in the loss measurement by the method of Professor Brailsford and Dr. Bradshaw.

The Chairman had then to apply the guillotine to further discussion in order to allow time for the authors to reply.

Professor Brailsford explained that the calibration technique used was developed primarily because it was found difficult to obtain reliable values of the specific heats of test materials. He made no claims that the method could be used for commercial testing. The object of the work had been to study the nature of the variation of hysteresis loss with flux density, so that the values at high flux densities could be estimated reasonably accurately from measured values at lower densities. It would require the development of new equipment to make the method suitable for measurements at temperatures above air temperature. There was some difference of opinion between Professor Brailsford and Mr. Butler on hysteresis losses, which stimulated an interjection from the latter during the professor's reply, but agreement was reached on the ultimate objective.

Dr. Street dealt principally with the discrepancy in tests by different methods which had been referred to by Mr. Martindale. These had been exhaustively investigated but not yet satisfactorily explained.

A most successful meeting then ended after a vote of thanks to the authors had been proposed by the Chairman.

A. H. M. A.

Spring Song?

Dr. J. C. West and his collaborators, who are studying automatic control at Manchester University, have now contributed a number of papers to the *Proceedings* in which the effects of non-linearities in the simpler kinds of systems are progressively being cleared up. On the 15th March, 1955, two such papers were presented. The first, by Dr. J. C. West and Mr. P. Nikiforuk, was on *The Transient Behaviour of Remote-Position-Control Systems with Hard-Spring Non-Linear Characteristics*, and the second, by Dr. J. C. West and Mr. J. L. Douce, was on *The Mechanism of Sub-Harmonic Generation in a Feedback System.*

Mr. M. Whitehead, welcoming the authors from the chair, remarked that it was almost a matter of habit for The Institution to expect a couple of papers in this series each year, and called on Dr. West to present the latest instalment.

This Dr. West did, with a most praiseworthy display of good blackboard technique. It must initially be explained what the first paper was about, because the members present, perhaps having in mind the desire that the Papers Committee have expressed for short and clear titles to papers, later teased Dr. West rather unmercifully by pretending that they did not know what he meant by a "hard-spring characteristic." Dr. Westcott, who has a lively wit, suggested that it might refer to the recent unseasonable weather, and, more seriously, Mr. J. J. Thompson pointed out that hardness related to difficulty of indentation, and that in any case the type of characteristic referred to could (with equal impropriety) be referred to as soft-spring.

What the paper refers to, of course, is the relationship between torque and error, and it considers the case in which increasing error causes the torque to increase more than in direct proportion.

In introducing the first paper, Dr. West related it to the others in the series, and particularly to the one read a year previously entitled *The Behaviour of a Remote-Position-Control Servo Mechanism with Hard-Spring Non-Linear Characteristics.* From this the present title differs mainly by the insertion of the word "transient." Two particular kinds of characteristic are considered, namely a cubic relationship between torque and error and a "segmentally linear" relationship, with two straight-line sections, the second being steeper than the first. The paper gives a clear analysis using phase-plane methods of the effect of such non-linearities in second-order systems, and the theoretical results are nicely illustrated by photographs of oscillographic traces of responses to step inputs and of phase-plane trajectories.

The second paper considers the remarkable fact that in such systems it is found that a sinusoidal input may result in an output that includes substantial components of frequencies that are $1/n$ of the frequency of the input, where n is an integer. The system may generate sub-harmonics. This is accounted for in the paper by the shift of phase of response at certain lower frequencies due to the presence in the non-linear element of components of input frequency. The system becomes unstable and capable of self-sustained oscillation at these lower frequencies. Phase-shift, as distinct from change of gain, occurs only at integral sub-multiples of the system frequency. The analysis uses "describing functions," and this provides a neat and satisfactory account of the phenomenon.

There was a useful discussion on these papers. It was largely on general topics, perhaps because the authors had left little to say about the mathematical relationships described. Dr. J. H. Westcott called attention to the fact that the authors were in error in stating that "describing function" methods came from across the Atlantic. They originated from the late Prof. P. J. Daniell in Britain in the early 1940's. He also raised a question of general interest by asking whether, in a

long investigation of this kind, it was really worth while publishing piecemeal, or whether it would be better to wait until it was possible to publish a comprehensive paper.

Mr. P. W. Grensted questioned the conclusion that hard-spring characteristics gave more damped responses than soft-spring characteristics, and presented some general results relating to the form of the envelope of responses, apparently indicating the reverse of this. The conflict was cleared up when it was pointed out that the form of equation assumed was not quite the same as the one in the paper, the non-linearity entering in a different way.

Appreciation was expressed in the discussion of the useful work that was being done by Dr. West and his collaborators in clarifying these difficult problems of the effects of non-linearity. Members wished to know how this work would develop in the future.

The authors all contributed their quota in the reply to the discussion, Mr. Douce making a very useful addition by discussing the criterion for stability of the sub-harmonic oscillations. Dr. West tried to satisfy the interest in his future plans by indicating his intention of linking the work in the future more closely with problems as they are encountered by industrial designers. A. T.

RADIO SECTION

Bee-Line

Four papers on high-frequency direction-finding were read at the meeting held on the 2nd March, 1955. The titles were: *Sources of Error in U-Adcock High-Frequency Direction-Finding*, by Mr. K. C. Bowen; *Some Comparative Directional Measurements on Short Radio Waves over Different Transmission Paths* and *Some Aspects of the Rapid Directional Fluctuations of Short Radio Waves reflected at the Ionosphere*, both by Mr. E. N. Bramley; and *On the Rapidity of Fluctuations in Continuous-Wave Radio Bearings at High Frequencies*, by Dr. W. C. Bain. Digests of the papers appear on pages 299–302.

The papers were concerned with the bearing errors associated with ionospheric irregularities and with the receiving site. They were of specialist rather than general interest, and the attendance at the meeting was consequently small. The interest aroused, however, is indicated by the fact that a dozen of those present took part in the discussion.

Mr. W. Ross opened the discussion and commented on the fact that present-day direction-finding equipment is much the same as that introduced roughly 20 years ago. But although in the intervening period there has been no striking improvement in the accuracy achieved, we have at least considerably improved our understanding of the problem. We know now that ionospheric irregularities set an ultimate limit to the performance of even the most immaculate direction-finding instrument. With this understanding has also come better methods of obtaining and interpreting the results; we also know more about how to place a number of direction-finding stations to obtain the best results by an averaging process.

Dr. R. L. Smith-Rose made some interesting comparisons with past work. He recalled the Institution paper read in 1920 by H. J. Round, a pioneer in the d.f. field. In this paper equipment was described which worked on medium frequencies using loop receiving aerials; "night effect" was not fully understood, although the cause was suspected. Remarkable confidence was placed in the results obtained during the day-time, and to illustrate this Dr. Smith-Rose recalled a story concerning the 1914–18 War. Sir Henry Jackson, who was First Sea Lord at the time, ordered the British Fleet to sea for the historic meeting with the German Fleet at the Battle of Jutland, after an observed bearing change of 1½° in the enemy transmissions had suggested a favourable battle position. Did present-day direction-finding inspire the same degree of confidence? Dr. Smith-Rose went on to answer his own question, saying that for the last two decades committees concerned with direction finding had set a target of 1° accuracy under all conditions, but we now know that this is beyond reach.

Another pioneer in the field of direction finding, Dr. R. H. Barfield, stressed the value of the modern statistical approach to the subject and suggested that instruments with longer base-lines might help to reduce site errors.

In the presentation of, and discussion on, the paper two unexpected difficulties were mentioned. One is that in many cases there were important discrepancies between the listed and actual positions of transmitting stations; indeed, Mr. Bowen mentioned one case where there was an error of over 100 miles. Another difficulty encountered in the more distant past was the operator who, trying to be helpful, gave the correct bearing (if he knew it) rather than the observed one; he even succeeded sometimes in getting bearings when there were no transmissions. Mr. J. F. Hatch and Mr. D. W. G. Byatt both suggested electronic averaging to eliminate this difficulty.

Mr. F. J. M. Laver asked whether ionospheric irregularities limit the effective gain of large-aperture aerials to an important extent. It was later suggested that the work described in the papers was concerned with relatively minor changes in the wavefront; nevertheless, these minor changes may cause appreciable bearing errors. There was no reason for believing that the gain of practical aerial systems was correspondingly affected to an appreciable extent.

The three authors made a brief reply. If they had used the same opening sentence as did H. J. Round when replying to a similar discussion 35 years ago, it would not have been inappropriate: "The errors in direction finding are of greater scientific interest than the practical questions involved." H. P.

Dinner-Dance

A successful dinner-dance arranged by the Committees of the Radio and Measurements Sections was held at

the Café Royal, London, on March 30th. Mr. C. W. Oatley, Chairman of the Radio Section, supported by Mr. M. Whitehead, Chairman of the Measurements Section, welcomed the guests, who included the President of The Institution and the Chairmen of the Supply Section and the London Students' Section. Mrs. Eccles, through indisposition, was unable to attend.

The President expressed his pleasure at being present that evening, and recalled that he had attended the Dinner of the Measurements Section earlier in the session, and had then said all the kind things about that Section which he could think of. He hoped to meet them again, in his Dr. Jekyll capacity, at Horsley Towers during their Summer Visit on June 17th next. The Radio Section was the largest of the Specialized Sections, and he hoped that all who could would use its services well and wisely. Under the chairmanship of Mr. Oatley the Section was very much alive, and he hoped it would go on from strength to strength.

An orchestra under the direction of Mr. George Jay provided music during dinner and dancing; about 250 members and ladies were present.

SUPPLY SECTION

On the 16th March, 1955, a paper was presented by Mr. R. T. Rushall and Mr. J. S. Simons entitled *An Examination of High-Voltage D.C. Testing applied to Large Stator Windings*. The investigation of which the results are recorded in the paper was carried out because of proposals that a simple d.c. high-voltage test could be used as a means of predicting whether the insulation of a winding was approaching a state of breakdown. The method has been particularly advocated in the United States and the idea is supported by several recent American papers.

The authors have made a very comprehensive investigation in which they have tested separate pieces of insulation with and without defects, complete insulated coils, and the windings of a turbo-alternator that had been in service for 15 years. Most of the tests measured the current flowing at various direct voltages, and were made so as to separate currents passing through the insulation and those leaking over the surface. Their conclusion is that any tests of this kind which did not damage the insulation would at the same time be extremely unreliable for indicating weakness of the insulation. A digest of the paper appears on page 302.

The eight contributors to the discussion, who represented the B.E.A. and several manufacturers, were practically unanimous in supporting the authors' conclusions. The principal reasons are first, that it is difficult to obtain sufficiently precise and consistent results with the very mixed types of insulation used on machine windings, and secondly, that a fault is localized in a small part, whereas the test gives an average for the whole winding. The latter point was graphically illustrated by one speaker, who imagined an alternator winding to be stretched out along the Embankment from Waterloo Bridge to Charing Cross.

Mr. J. D. Peattie, who proposed a vote of thanks from the chair, complimented the authors on their thorough work, and remarked that the fact that the results were entirely negative did not detract at all from its value.

B. A.

Dinner-Dance

There was a record attendance for the Annual Dinner-Dance of the Supply Section at the Café Royal on March 22nd. The 286 members and ladies were received by the Chairman, Mr. J. D. Peattie, and Mrs. Peattie, and after dinner there was dancing until midnight.

The programme followed the pattern of previous years, but despite the familiarity of the surroundings and of the course of the evening's entertainment, there was plenty of evidence that the occasion was at least as successful as similar functions in the past.

EAST ANGLIA

Farewell to District Meetings

On the 7th March, 1955, Mr. J. L. Davies read his paper on *Research in the Electrical Manufacturing Industry*, at the Crown and Anchor Hotel, Ipswich. This paper gives a peep behind the scenes into the work and problems and recruitment of the "back-room boys" of industry, who play a large part in keeping this country in the forefront of industrial development. The paper was accompanied by a most interesting set of exhibits and demonstrations, ranging from parts for jet aircraft to germanium and transistors and medical magnets. The paper was most enthusiastically received, and at the conclusion a vote of thanks was proposed by Mr. C. B. Wyatt.

This was the last Ipswich District Meeting to be held as such, and Mr. R. A. W. Connor, the convener, thanked the members of the informal committee who had greatly assisted him during the past six years. The Ipswich District has been combined with the Norwich and Cambridge District and the Cambridge Radio Group—to form the East Anglian Sub-Centre of the East Midlands Centre, so that the meetings in Ipswich next session will have the status of Sub-Centre meetings. R. A. W. C.

The last District Meeting to be held in Norwich took place at the Assembly House on March 10th, to hear Mr. D. Hicks give a lecture on *Fuel Supplies of the Future*.

Without the aid of films, lantern slides or models, and almost without notes, Mr. Hicks gave a talk which completely enthralled his audience. After considering every source of power available, he showed how greatly we still depended on coal in this country and that this dependence would create problems which would not be experienced in other countries, where coal was becoming relatively less important.

This was the final meeting in Norwich under the old

informal régime, and it will be remembered as one of our most successful ones. The only disappointment was that so few members came to share so enjoyable an evening.

Mr. J. A. Sumner took the chair and a vote of thanks to the speaker was moved by Mr. E. A. Pearce. J. A. S.

MANCHESTER

NORTH-WESTERN CENTRE

The Annual Dinner was held at the Midland Hotel, Manchester, on March 8th, and was attended by 440 members and guests.

They were received by the Chairman of the Centre, Professor E. Bradshaw, and Dr. Willis Jackson, a Vice-President of The Institution. The Toast of "The Institution" was proposed by the Lord Mayor of Manchester, Alderman R. S. Harper, in a very happy speech which created a most cordial atmosphere right from the beginning.

Dr. Willis Jackson responded to this toast, thanking the Lord Mayor, and referring to the long and increasing strength of this Centre in the city of Manchester and the surrounding district, in the progress of the electrical industry, not only of supply and distribution, but of the manufacture of large electrical plant and all other appliances. He also referred to his own long association with the North-Western Centre, which went back to his student days; and although he had for some time moved to London, he had now returned and he was glad to have been associated with a go-ahead Centre.

This reminded him that the Centre is shortly losing two very respected officials—Mr. L. H. A. Carr and Mr. A. L. Green. Mr. Carr has been with the Centre from his student days, and has held every office available to a member. He was Chairman of the Centre for the 1942–43 session, was the Hon. Secretary for several years before that, and has been the Hon. Treasurer for the last 12 years. The Centre will miss his advice and help, and all members wish him a long and happy retirement.

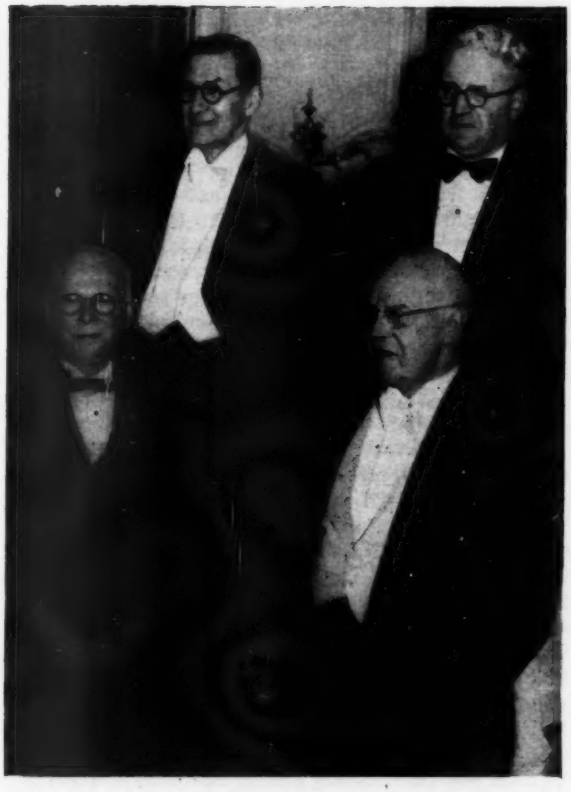
Mr. Green has been the Assistant Secretary of the Centre since its inception 52 years ago, and all its members deplore that his health demands his retirement. Everyone in the Centre knows him and will miss his presence very much at the meetings. The Centre owes him a great debt of gratitude. It is trusted that his health will improve and that he will be seen at many of the forthcoming gatherings.

The toast of "Our Guests" was proposed by the Chairman and was responded to by the Dean of Manchester, the Very Reverend H. A. Jones, with a delightful after-dinner speech.

Afterwards there was a grand reunion of old friends, and all recorded a very enjoyable evening.

Tenth Annual Lecture

The 10th Annual Lecture in co-operation with the University of Manchester was held at the Engineers' Club, Manchester, on March 1st, when Professor W. E. Morton spoke on *The Nature of Textiles*. The information so lucidly given proved of great interest to the ladies—who had been specially invited—and apparently no less to the members of the Centre. Prior to the lecture the Centre Committee and their ladies had met for dinner, and the evening was both intellectually and socially a great success.



Mr. Carr (standing left) and Mr. Green (sitting left) with the present Hon. Secretaries of the North-Western Centre

NORTH-WESTERN UTILIZATION GROUP

On February 4th, the Utilization Group of the North-Western Centre held their third Annual Dinner-Dance at the Lesser Free Trade Hall, Manchester. Some 170 members and guests were received by the Chairman of the Group Committee, Mr. P. A. Breton, and Mrs. Breton. Mr. Breton presided at the dinner.

The Group were honoured by the presence of the Chairman of the Centre, Professor E. Bradshaw, and Mrs. Bradshaw, and the Vice-Chairman, Mr. G. V. Sadler, and Mrs. Sadler. Dancing continued in a most genial atmosphere until 1 a.m. It was indeed a successful evening. T. T. E.

EDINBURGH AND DUNDEE

SCOTTISH CENTRE

The Faraday Lecture was this year delivered in two Scottish cities—Edinburgh and Dundee. In each of these towns, under the chairmanship of Mr. J. S. Hastie, Mr. T. B. D. Terroni's high ability as a speaker, as a film director and as the producer of a most fascinating array of demonstrations was received with ready acclamation by an audience of about 650; the purpose of the Faraday Lecture in setting before the public some important aspect of electrical development—in this case world-wide communications—was amply and admirably fulfilled. In Edinburgh the lecture was also given to about 1000 senior school-children.

On March 15th the South-East Scotland Sub-Centre held the outstanding meeting of its short history: the three papers by Professor G. W. O. Howe, Sir Edward Appleton and Dr. J. Thomson read in London at the Celebration of the Jubilee of the Thermionic Valve were repeated in Edinburgh. The thrill of hearing, on the same evening, Professor Howe, who was associated with Fleming, the inventor of the valve, Sir Edward Appleton, whose work in connection with radio-wave propagation is world famous, and Mr. E. B. Callick (in the unavoidable absence of Dr. Thomson), who gave a brilliant exposition of modern valve developments, is one that will be long remembered by those present. E. O. T.

READING

DISTRICT MEETING

With the object of providing an opportunity for members to bring forward and discuss any questions of mutual interest, the final meeting of the Winter Session, held on the 14th March, 1955, was an "Open Forum" centred around a group of specialists from among the members, comprising Messrs. R. Henbest (power stations), R. H. Abell (power transmission), P. J. Burton (electronics), W. H. Dyer (railway communication) and Major L. W. Lovegrove (Post Office telecommunication), under the chairmanship of Dr. T. E. Allibone. It was evident from the lively interest shown in the many and varied topics discussed that the evening was both enjoyable and instructive. Thanks to the speakers were expressed in highly appreciative terms by Mr. Forbes Jackson.

H. B.

OXFORD

DISTRICT MEETING

The final meeting of the session was held on the 9th March, 1955, when the Chairman, Mr. J. L. Taylor, welcomed Mr. E. P. Fairbairn, who read his paper on *Some Aspects of the Design of V.H.F. Mobile Radio Systems.*

After dealing with the methods of operation of the simplex, dusimplex and duplex systems, the characteristics of transmitters and receivers, including the merits of both amplitude- and frequency-modulated systems, the limitations due to Post Office restrictions, and the essential features of muting circuits, Mr. Fairbairn demonstrated a selective calling system. Using a main station transmitter and receiver and two mobile sets, he was able to show convincingly the points of advantage in this system.

A lively discussion followed, the main topic being the ease or otherwise of maintaining the equipment. Eventually the discussion had to be cut short, and a vote of thanks to the lecturer and his assistants was proposed by Mr. W. F. Sands.

The Chairman brought the meeting to a close and members then took the opportunity of inspecting the wealth of equipment which was exhibited. W. B. T.

NEWS *from abroad*

NEAR EAST

Mr. A. G. Coates, Oversea Representative of the Council for the Near East, gave a talk on the possibilities of telecommunication in that area on the 25th February, 1955, at the American University of Beirut. His audience consisted of engineering lecturers and students, and members of the public, including senior oil-company officials.

He began by saying that there is an urgent need for trained men in the service of telecommunication in the Near East to handle developments which are overdue. In the Near East, the main concern is with installation, maintenance and operation of telecommunication equipment, in contrast to manufacturing countries where there is much design and manufacture.

In dealing with telegraphy, Mr. Coates drew attention to facsimile telegraphy and to teleprinters. Facsimile telegraphy has special application to the Near East for transmitting Arabic script. It is at present in use locally for short distances; long-distance transmission is under development, but national electricity Grids to control the synchronous machines are a prerequisite.

Teleprinters are coming more into use, but their general adoption, except by the oil companies, inter-

national airports, etc., has been held up by the lack of a teleprinter sending in Arabic. Such a teleprinter is now available, and the use of these devices should therefore spread, although they require fairly expert maintenance. There are many teleprinters in use around Beirut for bookings and other important messages between airports and the agencies of air operating companies.

Mr. Coates went on to describe the significant items of telephone systems. He outlined the features of both manual and automatic exchanges, dealing, *inter alia*, with the Strowger step-by-step system. Basrah is noteworthy in that it was provided with an automatic telephone system as long ago as the early nineteen-twenties. The Baghdad exchange was not converted until 1944.

Continuing his talk, Mr. Coates discussed telephone and telegraph system engineering. In the Near East the question of connection between exchanges and between telegraph offices is a most important one. The centres of population are widely dispersed, but the community of interest among them grows as the distances separating them are effectively lessened by air lines. Several telephone administrations are interested in furthering projects for internal and international circuits. Amongst other activities each country is identified in some way with production and transport of oil, and the operations of the oil companies have stressed the need for adequate trunk services. Such companies, which have pipeline systems mainly miles away from the national telecommunication networks, have set up their own systems. These are generally well engineered with up-to-date equipment, because pumping of oil is absolutely dependent on efficient communication.

The development of public communication in the Near East has made rapid strides since the First World War, so far as urban areas are concerned. However, this is not true for communication between countries, and trunk lines are thus not yet of the same standard as are found elsewhere. There are two main defects, one being transmission efficiency, and the other a shortage of circuits, giving rise to delay. Owing to the distances involved, the cost of an underground trunk cable network, such as is used in Europe, would be prohibitive, and, as in South Africa, Australia and India, the alternative is the exploitation of land lines—whether existing or new—and the use of radio. Overhead lines exist between Jordan, Syria and the Lebanon, and these countries are in turn connected with Iraq; distances however are great. Wooden-pole routes are to be seen in Syria and in the Lebanon, many in Syria being transposed for 12-channel carrier working by the Government telephone administration. In the Lebanon there are substantial composite concrete and channel-iron posts, which are situated on the main roads, carrying transposed wires. These have to be particularly well set, at close intervals, in crossing the mountains where there is snow in winter. Wooden poles are used on less important roads.

One oil company uses closed Land Rovers for maintenance by linemen, and these men combine line inspection with patrolling for oil leaks. However, much linemen's work in the Near East is still carried out on horseback and even on camels.

Migrating birds can cause many faults to overhead lines in the nesting season. Although the desert appears to be empty and barren of foreign objects, they manage to build nests with surprising rapidity. These consist of twigs of shrubs and grasses, and a conglomeration of objects such as bits of blasting wire, welding rods, etc., left behind in the wake of pipeline construction. If the wires close to the transpositions and the insulators are painted with varnish the birds' nests do not cause many faults. For example, in 1943, 945 nests were removed between February 18th and May 18th, but these nests were responsible for only nine faults.

Under desert conditions the extra cost of fairly heavy wire appears to be justified. Certainly 70 lb cadmium–copper wire has lasted only a short time on desert routes, mainly owing to abrasion at the insulators; 300 lb wire is much more satisfactory and often results in economy in linemen.

Next the use of both carrier and radio equipment for junction and trunk channels was described. A notable example of an h.f. radio system is the one from Sidon to Kaisumuh, a distance of about 850 miles. The frequencies used on this system lie between 3 and 20 Mc/s, and the aerials have been designed to suit local propagation conditions and to reduce static interference from desert sandstorms.

Mr. Coates ended his talk by considering Near East communication in general. He said:

"There is little reason why the internal and external trunk systems of the countries concerned should not be tackled concurrently. To get internationally good results needs international planning to the highest standards by engineers of the countries concerned, working together to produce a satisfactory transmission plan.

"The equipment available nowadays, of the type mentioned in this talk, has been mainly developed since the Second World War, and it has the necessary performance. The provision of a first-class network would, after all, be nothing new in this part of the world. This statement may surprise you . . . but if so you are forgetting the immense and very satisfactory network set up during the war by the Forces for their own use. This network covered all the area we are considering, and considerably more, extending from Cairo west to Tripolitania, south to Khartoum, east to Teheran, and north to Adana. This was organized rapidly under the stress of war-time needs, using carrier equipment, the 3-channel systems of that period being employed for all the main links. Portable 4-channel systems were used as well. Teleprinters also covered the whole of this extensive and efficient network. . . .

"What could be done then can most certainly be done now, and in fact has been done by the oil companies. I hope that I have made it clear in this talk that with drive and initiative and the use of man-power and equipment which is available in the market, a great improvement is possible in present standards throughout the area."

OBITUARY

HERBERT STIRLING CARNEGIE

Herbert Stirling Carnegie, who died suddenly on the 4th February, 1955, was born on the 7th January, 1888. He had been associated with the English Electric Co. and its predecessors for 41 years.

He received his technical education under Professor Sylvanus Thompson at Finsbury Technical College, and later under Professor E. Arnold at Karlsruhe Technische Hochschule. After a long apprenticeship at Lawrence Scott, Norwich, and short periods of employment with other firms, he took a post with Siemens Brothers in 1914 at their dynamo works in London. In 1915 he left to join the Royal Engineers, in which he served throughout the war as a signal officer, fighting on the Somme and at Ypres and being awarded the Belgian Croix de Guerre.

He returned to Siemens in 1919, to work at Glasgow, and then at Liverpool on electrical marine contracts. From 1920 he was with the Rolling Mill Department of the English Electric Co. at London and then Stafford, becoming Chief of the Department in 1928. In 1930 he joined the Special Engineering Section, later becoming its Chief with responsibility for heavy electric drives for rolling mills and for ships. In 1941 he became Assistant, and two years later Deputy, to the Chief Engineer of the company, still retaining charge of Special Engineering. On reaching retirement age in 1953 he transferred to the staff of the Director of Engineering as a consultant.

Mr. Carnegie was an expert on electrical drives for steel mills. The drives for the first two hot-strip mills in Britain were engineered under his guidance. In the course of his duties he travelled very widely. He was one of a team of specialists who visited the United States in 1949 to study mechanical aids and handling devices under the auspices of the Anglo-American Council on Productivity. Later he was a member of a committee investigating the possibilities of the industrial development of Newfoundland.

He was widely esteemed for his technical ability and for his qualities as a gentleman. He always took an active interest in the welfare and progress of his assistants. This was particularly true of the younger members and students, in whose affairs he took an active part. His loss will be keenly felt among a very wide circle of friends and colleagues. He is survived by his widow and two daughters.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1935. In 1931 he was awarded an Extra Premium for an Institution paper on "The Electrical Driving of Rolling Mills." He was also a member of The Institution of Mechanical Engineers, The Institute of Metals, The Iron and Steel Institute and the Electrical Engineering Committee of the British Iron and Steel Research Association. E. B.

ROBERT GEORGE DE WARDT

Robert George de Wardt, C.B.E., who died suddenly on the 16th February, 1955, was born on the 22nd November, 1887, and received his general education at Gravesend Technical School. He studied mathematics and engineering in the evenings at the City and Guilds College, Finsbury, Birkbeck College, and the Northern Polytechnic, from 1902 to 1908.

In 1903, he joined the Post Office as a Telegraphist and subsequently transferred to the Engineering Department, being employed on power work in the Mount Pleasant sorting office. In 1908, he became an Inspector in the Test Branch, and in 1911 passed the Limited Competition for Assistant Engineer. At this time the Post Office had just taken over the National Telephone Co., and Mr. de Wardt was employed on the inventory and valuation of the company's plant, work for which he was commended by the Engineer-in-Chief. In 1917, he was transferred to the West District of Scotland and was responsible among other things for the installation of a number of early radio stations in the Hebrides.

He joined the newly formed Radio Branch of the Engineer-in-Chief's Office in 1922, and the following year took charge of Leafield wireless station. In this work and his subsequent work in charge of Grimsby beam-radio station, he was intimately connected with the development of long-distance radiocommunication.

In 1929 he returned to the Engineer-in-Chief's Office, and visited most of the European capitals to discuss radio matters. This was his last work on radio, for in 1931 he was promoted to Assistant Staff Engineer in the Telegraph Branch, where he was responsible for the introduction of the telex system. He left the Engineer-in-Chief's Office in 1933, becoming successively Assistant Superintending Engineer in the South Western District, Superintending Engineer in the South Eastern District (1935) and Superintending Engineer in the South Lancashire District (1936).

In the latter part of 1936 he came to London as the first Chief Regional Engineer of the London Telecommunications Region, and played an important part in setting up the new organization. After the Munich Agreement he was much concerned with safeguarding Whitehall communications. Promoted to Deputy Regional Director in 1939, he took a prominent part in the repair of damage caused by enemy air attacks and was responsible for the restoration of communications after the destruction of Wood Street exchange. He also began the mechanization of the London Toll service. He was made a C.B.E. in 1946 for services to the Post Office.

In the midst of all this activity Mr. de Wardt was able to find time to foster social activities within the Region and gave valuable support to the establishment of the London Telecommunications Region Amateur Sports Association and its Mutual Aid Fund. He retired in 1948. Throughout his long career, Mr. de Wardt showed a lively intelligence combined with a determination to get things done. The Post Office owes much to his energy, initiative and enterprise, and he will always be

remembered with affection and respect by all who served under him.

He joined The Institution as an Associate Member in 1921 and was elected a Member in 1935. F. I. R.

WILLIAM FRANCIS FURSE

William Francis Furse, who died on the 28th January, 1955, was born on the 27th August, 1884. He was the eldest son of Mr. W. J. Furse, J.P., founder of the firm of W. J. Furse and Co., Nottingham. He was educated at the Queen Elizabeth Grammar School, Mansfield, and University College, Nottingham.

He joined W. J. Furse and Co. as a trade apprentice in 1903, working in the shops and erecting and installing plant throughout the country. In 1912 he was appointed Managing Director of the firm, at the time when it was turned into a private limited company. In 1938 he became Chairman of the company.

Among his many interests were the Nottingham Society of Engineers, of which he was elected President in 1933–34, and the Electrical Industries Benevolent Association, of which he was one of the Junior Wardens. He also represented his company on the Electrical Contractors' Association for over 40 years, serving on the Sectional Board and sub-committees.

Mr. Furse was a well known and respected figure throughout the industry, and right up to the time of his sudden illness maintained an extremely active interest in the company and its individual members. All respected him, and he will be greatly missed. He leaves a widow, one son and three daughters.

He joined The Institution as a Student in 1903 and was elected an Associate Member in 1911 and a Member in 1919. He served on the Committee of the East Midland Sub-Centre for the periods 1919–23, 1933–37, and 1939–42. He was Chairman of the Centre in 1936–37. R. G. L. R.

CEDRIC PHILLIPS LOCKTON

Cedric Phillips Lockton, M.Sc.Tech., who died suddenly on the 20th February, 1955, was born on the 15th April, 1903. He was educated at Berkhamsted School and at the Manchester College of Technology, where he studied electrical engineering from 1920 to 1923 under Professor Miles Walker, a contemporary and friend of his father. During his time at Manchester, he received practical training at the College of Technology and at Electromotors, Ltd.

He obtained the degree of B.Sc.Tech. in 1923 and joined the British Electrical Plant Co. of Alloa, Scotland, to work on the design of small electric motors and dynamos, and of electrically-driven centrifugal pumps.

In July, 1924, he took his M.Sc.Tech. degree, which he had gained by a thesis on "A Portable Apparatus for Harmonic Analysis," and in September of the same year he was engaged by the Chloride Electrical Storage Co. as Assistant to the Chief Engineer. He specialized chiefly on the technical problems of portable and semi-portable batteries with particular reference to development work. During the 1939–45 War he was engaged largely in technical liaison with the Admiralty, War Office and Air Ministry on their many battery problems. In 1949 he was appointed Chief Engineer to the company and held this position at the time of his death.

A great interest of Mr. Lockton was astronomy and he was a member of the British Interplanetary Society. He enjoyed motoring and travel of any kind, and another of his personal interests was good music, which meant much to him. His father was Edward Lockton, the writer of many well-known songs. He leaves a widow but no children.

Mr. Lockton was a member of several B.S.I. committees, one of which had under his chairmanship recently completed the work on a Standard for the batteries of electrically-propelled (battery) vehicles.

He joined The Institution as a Student in 1922 and was elected a Graduate in 1928, an Associate Member in 1935 and a Member in 1950. E. R. S.

WILLIAM ALEXANDER HARRY PARKER

William Alexander Harry Parker, who died on the 15th January, 1955, was born on the 16th December, 1889. He was educated at the Swindon and North Wiltshire Secondary School and Technical Institution, and received his practical training with Electromotors Ltd., Manchester. He entered the electricity supply industry in 1909 and held appointments at Farnworth, Heywood and Manchester; in 1923 he was appointed Sales Engineer to the West Gloucestershire Power Co., and held this post until 1942, when he became a consultant on his own account, specializing in electrical agreements, law and arbitration cases, first in the Gloucester area and later in London. Mr. Parker was Chairman of the Thornton Cleveleys Press, Lancashire, and was electrical consultant to the National Farmers' Union, as well as several of the leading industrial firms in the country. He was a keen advocate of electrification for farms and rural dwellings, and was a member of the Rural Electrification Advisory Committee of the Electrical Development Association and of the National Register of Electrical Installation Contractors.

He was a member of the executive council of the Gloucestershire County Cricket Club for some years, and, more recently, a member of the M.C.C. During the Second World War he joined the Gloucester Home Guard and gained a commission. He is survived by his widow and a son.

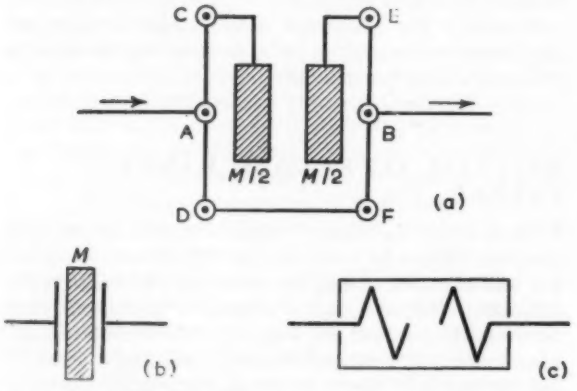
Mr. Parker joined The Institution as an Associate Member in 1919 and was elected a Member in 1943. He served on the Western Centre Committee from 1939 to 1942. He was also a Member of the American Institute of Electrical Engineers. F. F. F.

CORRESPONDENCE

Mechanical Networks

From DAVID MORRIS, B.Sc., D.Sc., *Associate Member*

In the February *Journal*, Mr. G. C. Tootill has described an arrangement of differential gear and flywheel which might be called a "relative moment of inertia," since it develops a torque proportional to the relative angular acceleration between its two shaft terminals. An equivalent of this for small translational motions is illustrated in Fig. 1(*a*), in which the two masses *M*/2 are assumed constrained to move in a straight line without

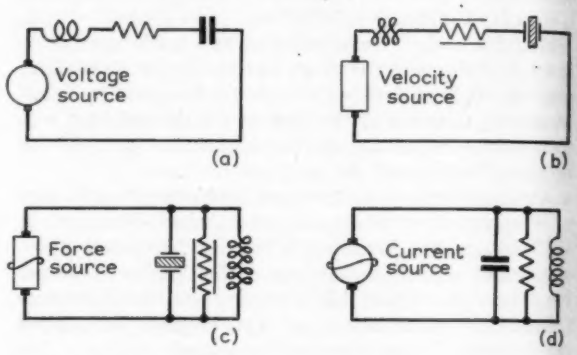


1 (*a*) *A relative mass M*
(*b*) *A symbol for relative mass*
(*c*) *A symbol for a symmetrical dash-pot*

rotation, the linkage ABCDEF being assumed to be without mass. This device may be called a "relative mass," since it transmits a force proportional to the relative acceleration between its terminal joints A and B. A symbolic representation of relative mass is shown in Fig. 1(*b*). An absolute mass may be regarded as a relative mass with one terminal fixed. A practical application for the relative moment of inertia is found in the phase advancement of synchros in servo systems.[1]

The great advantage of employing a two-terminal representation of mass is that mechanical linkages of masses, dash-pots and springs can then be represented by true networks, to which loop and node analysis and all the other techniques of electric circuit theory can be applied.[2]

A symbolism that I have found convenient in this connection may be of interest, since it possesses certain advantages over that conventionally adopted. This is exemplified in Fig. 2, which also illustrates the relationships of duality and analogy. Distinguishable symbols are employed for electrical and mechanical components, and they are chosen so that topological resemblance between circuit configurations is matched by a corresponding resemblance between circuit elements. The mechanical components are regarded as having a single line of action and, appropriately to this constraint, the interconnectors are interpreted either as transverse struts, or as flexible but incompressible wires that co-ordinate the longitudinal displacements round the circuit. The symbol for a current generator arises naturally from the well-known characteristics of an uncompensated armature-excited generator. Mechanical thrustors can be of two types: force sources that give an output force independent of output velocity, and velocity sources that give an output velocity independent of output force. The thrustor symbol for a force source has been chosen to be topologically analogous to the generator symbol for a current source. The dash-pot symbol can be regarded as derived from a slightly more functional symbol for a symmetrical dash-pot, as illustrated in Fig. 1(*c*). The dynamic analogue is so called because of the correspondence between mechanical force and electromotive force, and between particle velocity and charge velocity.



2 (*a*) *Prototype*
(*b*) *Topological analogue*
(*c*) *Dynamic analogue*
(*d*) *Dual of prototype*

Dr. David Morris is in the Department of Applied Electricity, University College of North Wales.

1 TUSTIN, A., MORRIS, D., and the METROPOLITAN-VICKERS ELECTRICAL CO.: British Patent No. 602204. 1940/1948.

2 GARDNER, M. F., and BARNES, J. L.: "Transients in Linear Systems" (Wiley, New York, 1942), I, Chap. II.
JEFFERSON, H.: "Electromechanical Equivalence," *Wireless Engineer*, December, 1944 XXI, p. 563.
RAYMOND, M. F.: "Analogies électriques et mécaniques," *Revue Générale de L'Électricité*, 1952, 61, No. 10, p. 465.

Technical Education and Training in Germany

From D. B. WELBOURN, M.A., *Associate Member*

As a member of the Verein Deutscher Ingenieure I should like to compliment Dr. K. R. Sturley on his remarkably complete survey of Technical Education and Training in Germany. May I, however, amplify it slightly?

The thorough training of far larger numbers of craft apprentices than is usual in this country is one of the reasons for the strength of the German and Swiss machine-tool industry; and the reserves of skilled craftsmen had a profound effect on the ease with which German industry was able to expand and decentralize during the 1939–45 war, while at the same time providing adequate numbers of craftsmen for the Armed Forces.

In the training of graduate engineers it appears to me that the objectives aimed at in the two countries are profoundly different. Here we try to produce at the end of three or four years graduates with a firm grasp of the elements of mathematical physics applied to engineering; in Germany, on the other hand, they try to produce at the end of four or five years a man capable of taking his place immediately in the design or drawing office of a firm. It is, I think, arguable that our system is a better training for first-class men and theirs for men of second-class or poorer ability.

Between the beginning of this century and 1939 the German *Technische Hochschulen* (or technical universities) turned out three times the number of graduate engineers per head of the population that we did, and a result of this—*pace* Dr. Sturley—is that far larger numbers of graduate engineers are to be found on the manufacturing side of German firms than is usual in this country outside the electrical industry. The advantages in the degree of collaboration between the design and manufacturing sides of German industry are notable; but let it be said at once that I am not referring to comparisons between the best firms here and there, but between the average firms. A further point that must strike the visitor to German firms is the large number of graduate engineers to be found engaged on mechanical-design work in drawing offices.

Finally, may I suggest that Dr. Sturley's last paragraph contains a confusion of thought? He says: "The *Technische Hochschule* method of training engineers does not appear to have any advantages over our more usual method of having an engineering faculty as part of a university." I have suggested that their method of training may have certain advantages, but this does not depend on the historical accident of the separation of *Technische Hochschulen* and universities in Germany. Indeed, the view is widely expressed in Germany that it would be beneficial if the *Technische Hochschulen* could be integrated into the universities; but such integration would not affect their method of training. What it would affect would be the ease with which teachers and students of engineering and allied subjects could mix with their colleagues in other faculties to their mutual benefit.

Mr. Welbourn is in the Department of Engineering, University of Cambridge.

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

The Secretary has been asked to draw attention to the following publications, copies of which can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given for each Standard are post free.

SPOT WELDING ELECTRODES (B.S. 807: 1955). 3s.

The previous edition of this Standard related only to shanks of spot-welding electrodes, and was issued to ensure interchangeability of electrodes in the sockets of electrode holders. The present edition covers the standardization of the electrode tips, with particular reference to the relationship between the welding surface and the holder. The dimensions have been standardized on the basis of common usage, to facilitate the production of electrodes.

Electrodes of the following types are dealt with: vertical centre; vertical offset; angle offset; and crank offset.

The sizes covered are $\frac{1}{4}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1 and $1\frac{1}{4}$ in, with the exception of the crank-offset electrode, for which only the $1\frac{1}{4}$ in size is given. A preference, however, is shown for $\frac{3}{4}$ in electrodes.

THERMAL-STORAGE ELECTRIC WATER-HEATERS (B.S. 843: 1954). 4s.

The scope of this revised Standard has been widened to include water-heaters with either copper or nickel-copper-alloy containers. The Standard now includes provision for dual-purpose water-heaters of the pressure type, and of 18–20 gal rated water capacity, having two groups of heaters, one towards the top of the container and the other near the bottom, the two groups being independently controlled. It also allows for the construction of non-pressure-type water-heaters with concealed fixings. The Standard has been brought into line with the requirements of the Ministry of Health Model Bye-Laws, Series XXI, where these are applicable.

FINE RESISTANCE WIRE FOR TELECOMMUNICATION AND SIMILAR PURPOSES (B.S. 1117: 1955). 2s.

This Standard, which supersedes the war emergency edition of 1943, applies to wires of circular cross-section, and of diameters in the range 0·000 5–0·012 in inclusive. It embraces

four classes of metallic resistance materials based on the requirements of temperature coefficient of resistance, working temperature and non-tarnishing characteristics. It was considered impracticable to include resistance tables for the large range of materials covered by the Standard, but requirements are stated for the tolerance on resistivity, resistance and uniformity of resistance. Maximum values for the temperature coefficient of resistance over given temperature ranges are specified for each of the four classes of resistance materials. Requirements are also laid down for the physical condition of wires as supplied by the manufacturer, and a mechanical test is specified for wires which are not ordered to a special temper by the purchaser.

The Standard is complementary to B.S. 115: 1954, which deals with metallic resistance materials for general electrical purposes.

DOMESTIC ELECTRIC WASHBOILERS (B.S. 1326: 1955). 3s.

In this revised edition of B.S. 1326, constructional details have, where possible, been omitted in favour of performance tests. The Standard specifies minimum requirements for domestic electric washboilers having heating elements of the clamp-on or immersion type, intended for use on voltages exceeding 30 volts (r.m.s.) a.c. or 50 volts d.c., but not exceeding 250 volts a.c. or d.c. It includes sections dealing with construction, materials, finish, and marking, and gives full information on tests, including rough-handling, stability, accessibility of live parts, performance and endurance.

CAPACITORS FOR CONNECTION TO POWER-FREQUENCY SYSTEMS (B.S. 1650: 1955). 5s.

This revised Standard, which supersedes B.S. 1650, Part 1: 1950, and Parts 2 and 3: 1952, is designed to bring the previous editions into closer agreement with the recommendations of the International Electrotechnical Commission. It is intended to apply primarily to capacitors having mineral-impregnated paper dielectric, and to cover continuously rated capacitors (e.g. for power-factor-correction purposes) and intermittently rated capacitors (e.g. for motor starting). Although large series capacitors rated at 1 kVAr or greater are not included within its scope, smaller series capacitors, such as may be used in some fluorescent-lamp circuits, are covered by the Standard.

The main changes in the new edition are increases in the permissible overload current for capacitors rated at not less than 1 kVAr, and a classification of the routine- and type-test clauses. Among the additional items which have been introduced are a stability test, and a test for the efficacy of the discharge device.

COVERED ELECTRODES FOR THE METAL-ARC WELDING OF MEDIUM-HIGH TENSILE STRUCTURAL STEEL (B.S. 2549: 1954). ½ PER CENT MOLYBDENUM STEEL ELECTRODES (COVERED) FOR METAL-ARC WELDING (B.S. 2493: 1954). 4s. EACH.

These Standards form part of a series for electrodes for metal-arc welding. B.S. 2549 deals with electrodes for the welding of steel of welding quality with a tensile strength of up to 43 tons/in^2, e.g. the type of steel covered by B.S. 968. The lack of such a specification in the past has meant that most specifications for the design of structures in high-tensile steel have had to prescribe the use of mild-steel electrodes, and, accordingly, the stresses permitted in the welds have not been comparable with the stresses permitted in the parent metal. The specification follows the form adopted in B.S. 639: 1952 in both its general and its test requirements. An additional test is the controlled-thermal-severity cold-cracking test, which is based on research work carried out by the British Welding Research Association.

B.S. 2493 covers the type of electrode commonly used for the welding of molybdenum and chromium–molybdenum steels, which operate at elevated temperatures. Basically the specification is the same as that of B.S. 639, except that the deposited metal is required to contain 0·5% molybdenum.

It is emphasized that in neither of these Standards has it been possible to cover the suitability of an electrode for a particular type of steel for a particular application. It will often be necessary to prove the suitability by appropriate tests, which are outside the scope of the Standards for electrodes.

CABLE SEALING BOXES FOR OIL-IMMERSED TRANSFORMERS. PART 1: BOXES FOR VOLTAGES UP TO AND INCLUDING 11 kV (B.S. 2562. PART 1: 1955). 7s. 6d.

This Standard deals with a range of cable sealing boxes of the type in which the cores of the cables end, and are connected to terminals, within the box itself. The Standard was prepared primarily for lead-covered cables, but account has been taken of the use of cables with an aluminium sheath. The boxes are classified according to voltage, current rating, number of poles and the number and size of cables and cable glands. Standard dimensions are given for a range of boxes which are for use indoors or outdoors, and for certain components of the boxes. In addition to seven tables, 18 Figures which illustrate the method of classification are included. The Figures also give standardized dimensions of the boxes in each class. Although the Standard does not purport to specify complete details of design and construction, some observations on this aspect are included for guidance. It is intended to issue later a second part covering boxes for voltages in excess of 11 kV.

CONTROL CHART TECHNIQUE (B.S. 2564: 1955). 10s. 6d.

This Standard gives practical guidance on the use of quality control in all processes of manufacturing to a specification. Written by Dr. B. P. Dudding and Mr. W. J. Jennett, it was first published by The General Electric Co. in 1944, and with the kind permission of the Director of the Research Laboratories of the G.E.C. it is now issued as a British Standard. The new Standard is essentially a practical manual describing procedures which have been found acceptable when introducing and operating quality-control methods as factory routine. Its main object is to assist production to a standard of quality, with the elimination of waste of labour and material.

The Standard is divided into two parts. The first concerns the utilization of results of measurement (quantitative data) and is of particular interest to manufacturing industry wherever articles or components are produced in quantity with dimensional limits of accuracy. The second part concerns the classification of a product by quality (qualitative data) and it is of use wherever sampling technique can be applied to regulate production. Directions are given for the construction and interpretation of control charts appropriate to various types of process, and some practical examples are given.

DRUMS FOR COVERED WINDING WIRES AND STRIPS (B.S. 2565: 1955). 2s.

At the present time many different sizes and types of drum are used for the supply of covered electrical winding wires and strips. There are many flange diameters, and for each diameter

several traverse dimensions. This causes considerable inconvenience, both to the wire coverers and to users in many different branches of the electrical industry. With the co-operation of these interests, the B.S.I. has therefore published this Standard, but in view of the comparatively long life of drums of this kind it will no doubt be a considerable time before the Standard can be fully operative. It is hoped, however, that all concerned will collaborate by changing over gradually to the standard drums. The range includes four different flange diameters, each with two traverse dimensions. The Standard gives full details of dimensions, and specifies the essential requirements for materials, construction, reeling, wrapping, labelling and marking. It also introduces a system of reference numbers for the identification of the drums. A new feature is the specification of a peg hole in each drum to take a braking device.

PHENOLIC LAMINATED SHEET (B.S. 2572: 1955). 4s.

This Standard specifies requirements for a number of types of phenolic laminated sheet which, in general, have good mechanical qualities, electrical insulating properties and resistance to corrosive influences. The tests specified are designed to assess, and differentiate between, the types; they have not been selected in consideration of any particular use to which the material may be put. The material is first divided into two groups: (*a*) where the mechanical properties in both directions are of the same order, and (*b*) where they are markedly different. The first group is then subdivided into four classes, according to whether the sheet is manufactured with an asbestos, cotton fabric, cellulose paper or wood-veneer filler. Altogether 14 different types of material are covered.

The Standard specifies requirements for: appearance, flatness, tolerance on thickness and marking of the material. Additionally, limits are laid down for the following physical properties: cross-breaking strength, impact strength, water absorption, electric strength (both flatwise and edgewise), insulation resistance after immersion in water, and crushing strength after heating. Methods of test are specified in the Appendices.

D.C. MOTORS FOR AIRCRAFT (B.S. G.146: 1955). A.C. MOTORS FOR AIRCRAFT: PART 1—THREE-PHASE 400 c/s SQUIRREL-CAGE INDUCTION MOTORS (B.S. G.147: 1955). 3s. 6d. EACH.

These Standards cover the general design and test procedure for a.c. and d.c. motors for use in aircraft, other than motors classed as engine starter motors.

NICKEL-WIRE THERMOMETER BULBS AND CONNECTORS FOR LIQUID TEMPERATURE MEASUREMENT IN AIRCRAFT (B.S. G.149: 1955). 2s. PLATINUM-WIRE THERMOMETER BULBS AND CONNECTORS FOR AIRCRAFT (B.S. G.148: 1955). 3s. 6d.

B.S. G.149 specifies the requirements for bulbs with temperature-sensitive elements made of nickel wire which are contained in a metal sheath and form a thermometer bulb for use in conjunction with electrical indicators made in accordance with B.S. G.114, "Direct Current Ratiometer Indicators for Aircraft." The nickel resistance elements are suitable for measuring temperatures up to 200° C.

B.S. G.148 deals with two types of bulb with temperature-sensitive elements made of platinum wire which are also suitable for use with indicators complying with B.S. G.114. The two types of bulb are distinguished by their functional differences. Type 1, normal-response bulbs, are designed for range of temperature operation rather than for speed of response. The Type 2 bulb is designed to achieve the highest practical response and is further characterized by reduced self-heating effects, but it is generally restricted to a lower maximum operating temperature, usually about 250° C. The principal application of the high-response bulb is for the measurement of air temperature. Both Standards contain details of connectors appropriate to the types of bulb with which they deal.

E.R.A. REPORTS

The Secretary has been asked to draw attention to the undermentioned Reports. Copies can be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. The price of each Report is given, and unless otherwise stated, the cost of postage on a Report is 3d.

E.R.A. REPORT REF. G/T298. "FLAMEPROOF ELECTRICAL APPARATUS: FLANGED JOINTS, ONE INCH IN RADIAL BREADTH IN MIXTURES OF 'STANDARD' TOWN'S GAS AND AIR." BY T. J. A. BROWN AND N. SIMPSON. 7s. 6d.

For explosive mixtures of "standard" town's gas and air, ignited in a bronze sphere having horizontal equatorial flanges one inch in radial breadth, the most incendiary internal mixture is that containing 18·5% of town's gas by volume. The most readily ignitable external mixture contains 17·0% of standard town's gas. Values for the maximum experimental safe gap, and the statistical maximum safe gap, reassessed, are included.

E.R.A. REPORT REF. G/T299. "MAXIMUM EXPERIMENTAL SAFE GAPS. A NOTE ON THE EMISSION OF FLAME THROUGH FLANGE GAPS." BY T. J. A. BROWN. 4s. 6d.

The fundamental difference between the British and American tests on flameproof equipment is the criterion of flameproofness: the non-appearance of flame external to the apparatus is the American criterion, whereas in Britain the non-ignition of an external mixture is the standard adopted. The tests described in this note illustrate the difference between the two standards.

E.R.A. REPORT REF. IB/T14. "AN ENERGY SURVEY IN THE SOMALILAND PROTECTORATE." BY E. W. GOLDING AND A. H. STODHART. 21s. (POSTAGE 4d.).

This survey was made, during the period from the 23rd April to the 28th May, 1954, with direct financial support from UNESCO and through the cordial co-operation of the Government of the Somaliland Protectorate, who gave valuable material assistance.

UNESCO established in 1950 an Advisory Committee for Arid Zone Research, which is concerned with the possibilities of development in arid and semi-arid areas. At a meeting in October, 1952, it was suggested that "energy surveys" like that described here should be made in several typical areas, and the Somaliland Protectorate was selected as being typical of the semi-arid areas not yet fully developed, but with potentialities. Suggestions are made for the utilization of natural energy resources, including wind power and solar radiation.

E.R.A. REPORT REF. L/T282. "THE MEASUREMENT OF POWER LOSS AT TEMPERATURES UP TO 100° C AND FREQUENCIES UP TO 100 Mc/s." BY E. RUSHTON AND G. RUSSELL. 7s. 6d.

The Hartshorn–Ward equipment for dielectric measurements on solid insulating materials over the frequency range 10 kc/s to 100 Mc/s has been adapted for measurements over the same frequency range at temperatures up to 100° C. The copper plates between which the sample of material is placed have been provided with heating elements which are embedded in them, and the temperature of each plate is measured by means of a thermocouple. The procedure is the same as that for the standard Hartshorn–Ward equipment. The standard capacitor formed by the copper plates is calibrated at a low frequency and at four temperatures in the range, and the capacitance and power factor of the sample at the various temperatures are measured by substitution in terms of this calibration.

E.R.A. REPORT REF. L/T286. "THE DIELECTRIC PROPERTIES OF ACENAPHTHYLENE STYRENE COPOLYMERS." BY J. V. L. PARRY. 3s.

This is one of a long series of reports from the National Physical Laboratory dealing with various aspects of the dielectric properties of materials. The copolymerization of acenaphthylene and styrene is of interest because the resultant copolymers have higher softening points than polystyrene.

E.R.A. REPORT REF. L/T292. "FURTHER IMPROVEMENTS TO THE VACUUM TORSION BALANCE AND SORPTION MEASUREMENTS ON POLYSTYRENE." BY A. G. DAY. 10s. 6d.

Descriptions of the means used to improve the accuracy of the balance are given; they include more accurate calibration and removal of the overshoot mentioned in E.R.A. Report Ref. L/T256 by reducing the radiometric forces acting on the specimen. Sorption measurements made on polystyrene at 50° C and up to 9·4 mm Hg water vapour pressure have been repeated with greater accuracy and extended to enable surface sorption to be estimated. Diffusion coefficients calculated from the sorption-rate curves are some 1 000 times smaller than those calculated from sorption and permeability constant as measured by Thomas and Gent (E.R.A. Report Ref. A/T92), indicating that Fick's law does not fully explain the sorption in polystyrene.

E.R.A. REPORT REF. L/T295. "THE ONSET OF BREAKDOWN IN GASES SUBJECT TO SUPERPOSED MICROWAVE AND UNIDIRECTIONAL ELECTRIC FIELDS." BY W. A. PROWSE, ELIZABETH LAVERICK AND W. JASINSKI. 7s. 6d.

A full description is given of the development of apparatus and technique required to determine the relation between breakdown stress and time of application: the present results indicate that the value of breakdown stress in polyatomic gases is determined in a time too short for the diffusion theory to apply, extension beyond 2 microsec being required. The apparatus enabled an auxiliary field to be developed at right angles to the microwave electric stress in a cylindrical resonator operating in the H_{011} mode. Electrons were introduced into the strongest position of the electric field by a naked spark derived from the operating pulse.

E.R.A. REPORT REF. L/T299. "ON THE MOTION OF SLOW ELECTRONS IN POLAR MATERIALS." BY S. ZIENAU. 12s. 6d.

The technique of canonical transformation is applied to various problems connected with the behaviour of a slow electron in an ionic crystal. The connection with previous and closely related work by Gurari is discussed.

E.R.A. REPORT REF. L/T303. "GROWING OF PEROVSKITE-TYPE CRYSTALS." H. F. KAY AND J. L. MILES. 7s. 6d.

In solid-state research, single crystals are often found to be indispensable for the final elucidation of the basic physical problems. This is very much the case with ferro-electric crystals, for although the more mechanically and chemically stable group (i.e. titanates) will find most practical application in the cheaper and easily worked ceramic form, it is evident that many of the properties of ceramics cannot be elucidated without a full knowledge of the crystal anisotropy.

A great deal of preparatory experimentation and inquiry has been performed, and although the results have been mostly negative, the work is recorded because it provides pointers to the directions in which subsequent effort could or should not be made. Also included are results obtained by other workers in the field.

E.R.A. REPORT REF. L/T314. "THE CASE FOR THE ADOPTION OF THE BRITISH PLASTIC YIELD TEST AS THE I.E.C. STANDARD." BY A. MORRIS THOMAS. 12s. 6d.

It is recognized that a simple type of plastic yield test for solid electrical insulants is a reasonable industrial requirement in spite of inherent limitations. Nevertheless such a test must provide information which is capable of at least some degree of practical application, if it is to be of any value in industry. Proposals for an international plastic yield test are now under consideration by the I.E.C., and probably inevitably the choice will be restricted to existing national (or quasi-national) standard methods.

The British test, being based on a constant temperature (or static) method, differs fundamentally from others which use an increasing temperature (or dynamic) method. Established rheological principles are applied to experimental data in a critical analysis of both the dynamic and static methods, the former being exemplified by the German (Martens) test. As a result, evidence is presented to show that, whereas the dynamic method is incapable of adequately fulfilling the purpose of an industrial plastic yield test, the static method as exemplified by the British test is probably as good as any which can be devised to meet the demand, and for this reason it is to be preferred as an international standard.

E.R.A. REPORT REF. W/T31. "ARTIFICIAL LIGHTING FOR PLANT GROWTH." BY A. E. CANHAM. 1s. 6d.

Light is one of the major factors controlling plant growth. By the appropriate use of artificial light greater control over the growth and development of plants is possible. It is a complex subject, and in this report the effects of different light conditions are discussed. Applications of artificial light in research and commercial horticulture are also considered, together with the merits of different light sources for these purposes.

E.R.A. REPORT REF. Z/T84. "THE PRE-NOVA STAGE OF A STAR." BY C. E. R. BRUCE. 6s.

The report discusses the evidence bearing on the pre-nova stage of a star, and purports to show that this is inadequate to warrant the generally held view that the pre-nova stage is a star of early type. Evidence is offered that the pre-nova stage is a star of later type.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

BOOKS

ABBOTT, A. L. 621.315.3
National Electrical Code Handbook
8th ed. 8vo. pp. 642. New York: McGraw-Hill, 1954. £2 7*s*. *
A guide to the general plan, scope and purpose of the 1953 Code.

ATKINSON, A. D. S. 621.327
Modern Fluorescent Lighting
2nd ed. 8vo. pp. 159. London: Newnes, 1955. 15*s*.
A practical work which explains the latest developments in fluorescent lighting techniques for factories, shops, public buildings and homes.

BANKS, H. F. 622 : 621.3
Electricity
2 vols. Cr. 4to. Vol. 1, pp. 287. Vol. 2, pp. 283. London: Virtue, 1952. £3 *
Intended for students preparing for Higher National Certificates in Mining, Mining Electrical Engineering, Mine Managers' Certificates, A.M.E.M.E., and A.M.I.Min.E. Volume one deals mainly with the theory of the subject and volume two with the machinery and equipment used in mines.

BECKETT, C. S. 621.31
Generation and Transmission
3rd ed. 8vo. pp. 130. London: Blackie, 1954. 8*s*. 6*d*. *
Deals with both the steam and electrical sides of modern generating stations and with overhead and underground transmission systems.

BEYAERT, R. 621.314.2
Calcul des Petits Transformateurs (Design of Small Transformers)
8vo. pp. 398 Paris: Dunod, 1954. 2,900 fr. (£3 2*s*.) *
Contains a chapter on welding transformers.

DE FOREST, L. 92(De)
Father of Radio: the Autobiography of Lee de Forest
Roy. 8vo. pp. 502. Chicago: Wilcox and Follet, 1950. £2 *
A lengthy account of school and college days is followed by a great deal of detail on the author's work and experiences in the early days of radio telegraphy. The development of the three-electrode valve is part of this story and of subsequent work in connection with radiotelephony and broadcasting. Talking pictures, television and short-wave diathermy were later interests.

DENIS-PAPIN, M., & VALLOT, J. (EDITORS) 621.31(03)
Notes & Formules de l'Ingenieur. Vol. 4
23rd ed. Cr. 8vo. pp. 2146. Paris: Éditions Albin Michel, 1955. 5,700 fr. (£5 17*s*.)

DE VILLE, E. 537
Electricity
F'cap 8vo. pp. 159. Harmondsworth: Penguin Books, 1955. 2*s*. 6*d*. *
A simple account, for the layman, of the discoveries in electricity and magnatism which have been made through the ages and up to the present time. The story, although very condensed, is clearly told.

DE VRIES, L. 413 = 30
English-German Technical and Engineering Dictionary
Roy. 8vo. pp. 997. London: McGraw-Hill, 1954. £7
Contains over 130000 terms including many peculiar to radar, television electronics, rocket propulsion and nuclear engineering.

DIEBOLD, J. 658.2
Automation: the Advent of the Automatic Factory
Cr. 8vo. pp. 191. New York: Van Nostrand, 1952. 22*s*. 6*d*. *
A discussion of the possibilities, limitations, and social and economic consequences of automatic production in factories. Fully automatic processes are not obtained by applying automatic control to existing machinery, but by consideration of the process as a whole, and may involve the redesign of product, process, or the machinery. This book will be reviewed in a future issue.

DOW, W. G. 621.38
Fundamentals of Engineering Electronics
2nd ed. 8vo. pp. 641. New York: Wiley. London: Chapman and Hall, 1952. £3 8*s*. *
Deals comprehensively with the fundamental principles and behaviour of vacuum tubes and the physics of semi-conductors. Then discusses circuit principles of amplifiers, oscillators and transit-time devices. Photoelectric cells and gas-filled tubes are also considered.

DUNN, C. H., AND BARKER, H. J. 621.317
Electrical Measurements Manual
8vo. pp. 116. New York: Prentice-Hall, 1952. 30*s*. *
An elementary introduction to laboratory techniques, the various types of laboratory meters and bridges, and cathode-ray oscillographs, arranged as a series of laboratory experiments.

DWIGHT, H. B. 621.315.01
Electrical Elements of Power Transmission Lines
8vo. pp. 192. New York: Macmillan, 1954. 30*s*. *
A book for students which assumes only an elementary knowledge of trigonometry and calculus. Discusses load studies, symmetrical components for short-circuits, cost of resistance loss, temperature rise of conductors and the calculation of resistance by the use of geometric mean distances. There are many problems to be worked by the student with answers.

ERNST, R. (EDITOR) 413 = 30
Technisches Wörterbuch. Vol. I German-English
2nd enlarged ed. Cr. 8vo. pp. 627. Wiesbaden: Brandstetter, 1954. £2 4*s*. (both volumes)

ERNST, R. (EDITOR) 413 = 30
Technisches Wörterbuch. Vol. II English-German
2nd enlarged ed. Cr. 8vo. pp. 671. Wiesbaden: Brandstetter, 1954. £2 4*s*. (both volumes)

EVANS, W. R. 621–52
Control-system dynamics
Roy. 8vo. pp. 282. London: McGraw-Hill, 1954. £2 10*s*. *
Introductory chapters deal with the principles of control systems and typical components. The remainder of the book is concerned with the mathematical solution of problems.

FETT, G. H. 621–52

Feedback Control Systems

8vo. pp. 370. New York: Prentice-Hall, 1954. £4 *

Introductory chapters review feedback control systems and components. Discusses solution of differential equations of steady-state and transient conditions, conditions for stability and the Nyquist criterion, and the analysis and synthesis of complex systems. There are problems at the end of each chapter and references to further reading.

GOLDSMITH, A. N., AND OTHERS (EDITORS) 621.397

Television. Vol. 6 (1949-1950)

8vo. pp. 429. Princeton, New Jersey: Radio Corporation of America, 1950. 22*s*. *

A collection of articles which were published during the period 1949 to June 1950, mainly in American periodicals.

GREATHOUSE, G. A., AND WESSEL, C. J. (EDITORS) 620.19

Deterioration of Materials

Roy. 8vo. pp. 835. New York: Reinhold, 1954. £4 16*s*. *

This monumental work is based on research carried out during the war years and since in the U.S.A. into the causes and prevention of the deterioration of equipment used for military purposes. It surveys metals, wood, paper, textiles, plastics, paints, and electrical and other equipment. Climatic conditions in various parts of the world are discussed, physical, chemical and biological causes of deterioration are explained together with the steps to be taken to provide adequate protection. There is an extensive bibliography to each chapter, and the book contains many photographs illustrating the types of deterioration encountered.

GUTHRIE, L. O. 8.08

Factual Communication: a Handbook of American English

8vo. pp. 448. New York: Macmillan, 1948. 30*s*. *

This is a book on how to write and speak properly and simply so as to convey information clearly, and to be understood. It also deals with the way to find and use the reference material (sources of information) in libraries.

HEINE, G. M., AND DUNLAP, C. H. 621.3 (084)

How to Read Electrical Blueprints

2nd ed. 8vo. pp. 318. Chicago: American Technical Society, 1954. 38*s*.

Explains the symbols and diagrams relating to domestic and large installations, and to motors, generators and their control equipment. It is an American book and relates to American practice.

KEMPE 62 (03)

Engineer's Year-Book for 1955. Vols. 1 and 2

60th ed. Cr. 8vo. pp. 1345, 1413. London: Morgan, 1955. £3 15*s*.

A compendium of modern practice in civil, mechanical, electrical, marine, gas, aeronautical, mining and metallurgical engineering.

KENDALL, J. 92(Far)

Michael Faraday. Man of Simplicity

8vo. pp. 196. London: Faber, 1955. 12*s*. 6*d*. *

There are quite a number of biographies of Faraday but this one certainly must rank amongst the best, for it is easy reading and very informative.

KIVER, M. S. 621.397

Television Simplified

4th ed. 8vo. pp. 537. New York and London: Van Nostrand, 1954. £2 1*s*. *

A straightforward, simple, but detailed explanation of the way a television receiver works.

KNIGHT, S. A. 621.396.96

Fundamentals of Radar

2nd ed. Sm. 8vo. pp. 158. London: Pitman, 1954. 15*s*. *

A theoretical survey intended to explain the principles of pulse generators and receivers in terms of ordinary radio engineering. Complete radar systems are not considered. This edition contains additional notes on waveguides, the cavity magnetron, line-type pulsers and t-r cells.

LAIBLE, T. 621.313.3

Die Theorie der Synchronmaschine (The theory of the synchronous machine)

8vo. pp. 128. Berlin: Springer-Verlag, 1952. 24*s*. *

LYON, W. V. 621.313.3

Transient Analysis of Alternating-Current Machinery: an application of the method of symmetrical components

8vo. pp. 318. New York: The Technological Press of Massachusetts Institute of Technology and Wiley. London: Chapman and Hall, 1954. £2 16*s*. *

Uses an analysis based on the Kirchoff differential equations that apply to the machine and the connected system. Shows how Fortescue's method of symmetrical components can be used to determine the transient behaviour under different operating conditions.

McPHERSON, D. H., AND RAY, P. N. 526

Surveying: Solutions to B.Sc.(Eng.) Examination Questions, London University, External

8vo. pp. 152. London: Macdonald, 1955. 18*s*. *

A collection of worked examples and questions to be answered for students preparing for a University Degree or for the examination of The Institution of Civil Engineers.

MARTIN, T. L. 621.396.029.6

Ultrahigh Frequency Engineering

8vo. pp. 456. New York: Prentice-Hall, 1950. £3 4*s*. *

Describes the theory and technique of circuits and component parts of U.H.F. systems rather than the systems as a whole. Discusses wave-shaping and trigger circuits, amplifiers, transmission lines, waveguides and resonators, klystrons and magnetrons. A knowledge of the calculus is assumed and differential equations are used in the text, but the steps involving their use are also fully explained.

MOLLOY, E. (EDITOR) 621.315.3

Electric Wiring (Domestic): A practical work for installation engineers, contractors and electric wiremen

5th ed. Sm. 8vo. pp. 274. London: Newnes, 1954. 8*s*. 6*d*. *

Brought into line with the 12th edition of the I.E.E. wiring regulations and the 1954 supplements. Deals with accessories for ring-main circuits and the latest instant-start and circular fluorescent lamps and luminescent panels.

POINCARÉ, H. 535.13

Electricité et Optique: la lumière et les théories électrodynamiques. (Electricity and Optics: light and its electrodynamic theories.)

2nd ed. 8vo. pp. 641. Paris: Gauthier-Villars, 1954. 2,000 fr.

PUTNAM, P. C. 621.311.003

Energy in the Future

8vo. pp. 564. London: Macmillan, 1954. £4 10*s*. *

Based on world population growth predictions, which are discussed in considerable detail; domestic and industrial energy-consumption estimates; and an assessment of energy reserves of all kinds, nuclear energy possibilities, and solar and other inexhaustible energy sources.

RICHARDSON, K. I. T. 513.383

The Gyroscope Applied

8vo. pp. 384. London: Hutchinson, 1954. 30*s*. *

This book is based on "The Gyroscope and its Applications," published in 1946, but includes much information then secret. It describes simply the basic principles and applications of the gyroscope. Modern uses for stabilizers for marine and aeronautical navigational instruments, and for military purposes are then considered, and the monorail car is described. The book will be reviewed in a future issue.

RIDEOUT, V. C. 621.385

Active Networks

8vo. pp. 501. London: Constable, 1954. £2 2*s*. *

A comprehensive textbook on valve amplifiers, modulators and transistor circuits considered as active networks. The final chapter deals with noise and with information theory. Bibliographical references and problems to be worked are given at the end of each chapter. The book is reviewed on page 330.

RODENHUIS, E. 621.385

Electronic Valves in A.F. Amplifiers

8vo. pp. 153. Eindhoven: Philips, 1954. 10*s*. 6*d*. *

This book is written mainly for amateurs who wish to design and make their own equipment. Nevertheless the practical information it gives, including guidance on the layout and relative position of components, will be useful also to the professional designer. Various amplifiers of up to 100 watts output based on Dutch valves are described.

SAY, M. G. (EDITOR) 621.318

Magnetic Alloys and Ferrites

8vo. pp. 206. London: Newnes, 1954. *

The first chapter deals with modern views on ferromagnetic theory. Subsequent chapters describe new magnetic materials and their applications, including magnetically soft materials, grain-oriented silicon-iron alloys, ferrites, and grain and domain oriented nickel-iron alloys.

SCHOTTKY, W. 621.315.59

Halbleiter-Probleme. (Semiconductor Problems.) Vol. 1

Roy. 8vo. pp. 387. Braunschweig: Vieweg, 1954. £2 15*s*.

SCIENCE MASTERS' ASSOCIATION 37

The Teaching of Electricity with Special Reference to the Use of M.K.S. Units: A Report of a Sub-Committee of the Science Masters' Association

8vo. pp. 135. London: Murray, 1954. 10*s*. 6*s*. *

Recommends that the rationalized M.K.S. system of units be adopted in place of the three systems now used; and that the quantitative treatment of magnet poles be omitted from the school syllabus, to permit the introduction of more important topics, and the development of electromagnetism on new lines. Sets forth an entirely new syllabus, with teaching notes, definitions, theoretical proofs, and experiments. The book will be reviewed in a future issue.

SKROTZKI, B. G. A. (EDITOR) 621.315

Electric Transmission and Distribution

8vo. pp. 448. New York: McGraw-Hill, 1954. £2 14*s*. 6*d*. *

The first 80 pages consists of a simple treatment of the theory of electricity to explain the operation of generators and circuits. Succeeding chapters describe in the same vein the circuits and equipment used in a.c. and d.c., low-, and high-voltage systems.

SKROTZKI, B. G. A. 621.311.003

Electric System Operation

8vo. pp. 370. New York: McGraw-Hill, 1954. £2 9*s*. *

A practical review of the engineering aspects of electric utility systems in the U.S.A. Discusses the economic use of fuel, generating, transmitting and distributing equipment, relays, load-dispatching and control, communications equipment, operating costs and rate schedules.

SMITH, C. J. 537

A General Degree Physics, Part 5. Electricity and Magnetism

8vo. pp. 751. London: Arnold, 1954. £2 5*s*. *

This book goes rather beyond the normal treatment of electricity and magnetism for a B.Sc. General Degree. It deals with electrostatics and magnetism and then current electricity, and the subject of alternating currents and transients is treated more fully than usual.

SMYTH, W. R. 537

Static and Dynamic Electricity

2nd ed. 8vo. pp. 636. New York and London: McGraw-Hill, 1950. £3 12*s*.

This book for advanced students assumes a sufficient knowledge of elementary calculus to follow the mathematical developments which are used. The theories of electrolytic conduction, thermionic emission, photo-electric phenomena, thermo-electric effects, and machines are not dealt with, but the treatment of electromagnetic waves has been expanded in this edition, which has been brought up to date by the use of rationalized M.K.S. units and modern nomenclature. Each chapter concludes with problems, many of these from Cambridge University examinations.

SOCIETY OF THE PLASTICS INDUSTRY 679.5

Plastic Engineering Handbook

Roy. 8vo. pp. 848. New York: Reinhold, 1954. £6

This very comprehensive work is due to the efforts of a number of technical committees each assigned to deal with one or more of the twenty chapters. The descriptions of techniques and processes are augmented by photographs and diagrams. There is a wealth of data for reference purposes and a chapter on voluntary American standards.

STARR, A. T. 621.39

Telecommunications

8vo. pp. 451. London: Pitman, 1954. 35*s*. *

Covers the syllabus of the subject for the London University Degree. The first part of the book deals with systems and circuits; the later chapters deal more particularly with circuit theory, transients, networks, microwave techniques, waveguide theory, and the mathematical methods—Fourier analysis, the operational calculus and the Laplace transform.

STÄGER, H. 621.315.6

Werkstoffkunde der Elektrotechnischen Isolierstoffe (Technology of electrical engineering insulating materials)

Cr. 4to. pp. 470. Berlin: Gebrüder Bornträger, 1955. £7

This book will be reviewed in a future issue.

STEVENSON, O. J. 92(Bell)

The Talking Wire: the Story of Alexander Graham Bell (Men of the Modern Age: 4)

8vo. pp. 158. London: Bodley Head, 1954. 9*s*. 6*d*.

An interesting account of the life of Alexander Graham Bell. The

story of his interest in the telegraph, and later the possibility of actually transmitting speech, is told in the later chapters.

STEWART, K. H. 538.22

Ferromagnetic Domains

8vo. pp. 186. Cambridge: University Press, 1954. 25*s*. *

Considers in detail the various factors affecting the behaviour of individual domains and shows how, by paying attention to certain effects of demagnetizing fields, a consistent picture can be built up of the way domains are combined in ferromagnetic substances. The book is reviewed on page 330.

STOKER, J. J. 534

Nonlinear Vibrations in Mechanical and Electrical Systems

8vo. pp. 291. New York and London: Interscience, 1950. £2 8*s*. *

Discusses briefly the theory of linear vibrations. Then considers free vibrations of undamped systems with non-linear restoring forces, free oscillations with damping and the geometry of integral curves, and forced oscillations of systems with non-linear restoring forces. Self-contained oscillations are dealt with, and the final chapter is on the stability of non-linear oscillations. There are six appendices with rigorous treatments of a number of mathematical questions.

THORNDIKE, A. M. 539.18

Mesons: a Summary of Experimental Facts

8vo. pp. 248. New York and London: McGraw-Hill, 1952. £2 2*s*.

A descriptive and non-mathematical account of present knowledge of meson physics.

VON HIPPEL, A. R. (EDITOR) 537.226

Dielectric Materials and Applications; Papers by twenty-two contributors

4to. pp. 448. New York: Technology Press of M.I.T. and Wiley. London: Chapman and Hall, 1954. £7. *

Deals first with the theory of the subject in two parts—macroscopic properties and dielectric properties; describes measuring techniques for permittivity, permeability, microwave spectroscopy, and magnetic resonance. Dielectric materials and their use in equipment and as devices such as rectifiers, magnetic amplifiers, etc., are then reviewed. Tables and curves giving data are included.

VON HIPPEL, A. R. 537.226

Dielectrics and Waves

4to. pp. 294. New York: Wiley. London: Chapman and Hall, 1954. £6 8*s*. *

The term dielectrics is used to refer not only to those materials known as insulators, but to all non-metals, and even metals as a boundary case, when considering their interaction with electric, magnetic, or electromagnetic fields. Considers polarization, magnetization, and conduction, dealing first with the macroscopic and then with the molecular approach.

VON TERSCH, L. W., AND SWAGO, A. W. 538.551

Recurrent Electrical Transients

8vo. pp. 407. New York: Prentice-Hall, 1953. £4 2*s*. 6*d*.

Concerned with the analysis of circuits used for wave-shaping—RC, RL, clipping, sweep, trigger and multivibrator circuits. It is a book for students and contains many worked examples and problems to be worked, as well as a bibliography of references to further reading.

WALSH, J. W. T. 628.9

Textbook of Illuminating Engineering (Intermediate Grade)

2nd ed. 8vo. pp. 212. London: Pitman, 1954. 28*s*. *

A book for students preparing for the City and Guilds examination in Illuminating Engineering (Intermediate Grade). This edition has been brought into line with the revised syllabus. A new chapter on colour has been added for students taking this subject in the final part of the Institution Examination.

WEBER, E. 538.551

Linear Transient Analysis. Vol. 1. Lumped-Parameter Two-Terminal Networks

8vo. pp. 360. New York: Wiley. London: Chapman and Hall, 1954. £3 *

Gives an extensive and critical review of classical and operational methods of analysis leading up to the Laplace transform and Fourier integral methods with illustrations of practical circuit problems.

WELLAUER, M. 621.315.027.3

Einführung in die Hochspannungstechnik (Introduction to High-Voltage Engineering)

8vo. pp. 331. Basle, Stuttgart: Verlag Birkhäuser, 1954. £2 10*s*. 6*d*.

WESTINGHOUSE ELECTRIC CORPORATION 621.316.9

Silent Sentinels: Westinghouse protective relays

4to. pp. 242. New Jersey: Westinghouse Electric Corporation, 1949. $3.50. *

A series of articles or chapters on applications of protective relays and actual Westinghouse equipment. The bibliography is considerably larger than that in the earlier edition.

WIENER, N. 621–52

The Human Use of Human Beings

2nd ed. 8vo. pp. 199. London: Eyre and Spottiswoode, 1954. 18*s*. *

So much of this book has been rewritten that those who were interested in the original will need to read this revised edition.

WILLIAMS, R. G. 628.9

Lighting for Color and Form: Principles, equipment and applications

8vo. pp. 354. London: Pitman, 1954. £2 5*s*. *

Deals with theoretical considerations concerning vision, colour and illumination, including additive colour-blending and colour quality in fluorescent white lighting. Equipment and techniques of coloured and directional lighting are described with a discussion of psychological and aesthetic factors, and applications are illustrated. The book was reviewed in the March Journal.

WILKES, M. V., AND OTHERS 518.5

The Preparation of Programs for an Electronic Digital Computer; with special reference to the EDSAC and the use of a library of subroutines

Roy. 8vo. pp. 184. Cambridge, Mass.: Addison-Wesley Press, 1951. 37*s*. 6*d*. *

To solve a mathematical problem by the use of a computing machine it is necessary to resolve the problem into a sequence of simple stages. The book describes the way sequences have been systematically prepared, and a library in which they are filed. The sequences are in the form of punched tapes.

YOUNG, J. F. 62.002.3

Materials and Processes

2nd ed. 8vo. pp. 1086. New York: Wiley. London: Chapman and Hall, 1954. £3 8*s*. *

This book is written for students and contains questions on each chapter; it is nevertheless a reference work containing much useful

data. It reviews the properties and suitability of metals and non-metals for manufacturing purposes and includes consideration of electrical and magnetic properties. Processing techniques and methods of inspection, non-destructive testing and quality control are then described.

ZABORSZKY, J., AND RITTENHOUSE, J. W. 621.315.01

Electric Power Transmission: the Power System in the Steady State

8vo. pp. 686. New York: Ronald Press, 1954. £5 *

An introductory chapter gives a practical description of the basic structure of distribution systems, switching arrangements, lines and cables. Discusses the characteristics and constants of lines and underground cables, the interconnection of systems and load-frequency regulation, and power-system economy. Contains worked examples, problems to be worked and bibliographical references. The book will be reviewed in a future issue.

ZWORYKIN, V. K., AND MORTON, G. A. 621.397

Television: the Electronics of Image Transmission in Color and Monochrome

2nd ed. 8vo. pp. 1052. New York: Wiley. London: Chapman and Hall, 1954. £7. *

This new edition, brought up to date, and greatly enlarged, deals comprehensively with the whole field of television engineering, and considers the fundamental physical principles, system principles, components, colour television and industrial applications. The book is reviewed on page 331.

OTHER PUBLICATIONS

ASSOCIATION OF ENGINEERING AND SHIP-BUILDING DRAUGHTSMEN

The Installation of Underground Electric Cables, by N. J. Hicks

8vo. pp. 34. Richmond: Association of Engineering and Shipbuilding Draughtsmen, 1954. 3*s.*

BETTRIDGE, B. R.

Transistors and Crystal Diodes

8vo. pp. 72. London: Norman Price, 1954. 5*s.* *

BRITISH ELECTRIC POWER CONVENTION

Proceedings of the Sixth British Electric Power Convention, Eastbourne, 14th to 18th June, 1954

8vo. pp. 500. Northampton: Lea and Co. Ltd., 1954.

BRITISH PRODUCTIVITY COUNCIL

Industrial Engineering: Report of a visit to the U.S.A. in 1953 of a British Specialist Team on Industrial Engineering

8vo. pp. 113. London: British Productivity Council, 1954. 5*s.*

BRITISH TRANSPORT COMMISSION

Modernisation and Re-equipment of British Railways

4to. pp. 36. London: British Transport Commission, 1955. 3*s.* 6*d.*

COLONY AND PROTECTORATE OF KENYA 654.16

Report of the Kenya Broadcasting Commission, June, 1954

8vo. pp. 47. Nairobi: Government Printer, 1954. 2*s.*

COMMISSION MIXTE INTERNATIONALE POUR LES EXPÉRIENCES RELATIVES À LA PROTECTION DES LIGNES DE TÉLÉCOMMUNICATION ET DES CANALISATIONS SOUTERRAINES (C.M.I.)

7e Reunion Plénière, Paris, 24–31 mai 1954

4to. pp. 118. Castels, Lalou: C.M.I., 1954.

COMMITTEE ON DEPARTMENTAL RECORDS

Report, July 1954 (Cmd. 9163)

8vo. pp. 88. London: H.M.S.O., 1954. 3*s.*

CONGRÈS INTERNATIONAL D'ÉLECTROTHERMIE

3e Congrès, Paris, du 18 au 23 mai 1953, organisé par le Comité Français d'Électrothermie.

2 vols. 4to. Vol. 1, pp. 689. Vol. 2, pp. 620. Paris: Comité Français d'Electrothermie, 1954.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

The Dielectric Properties of Wood, by R. F. S. Hearmon and J. N. Burcham (Forest Products Research Special Report No. 8)

8vo. pp. 19. London: H.M.S.O., 1954. 1*s.* 6*d.*

EISLER, P.

Printed Circuits and Their Future Prospects

4to. pp. 6.

Reprinted from the "British Printer," July–August, 1954.

FEDERATION OF BRITISH INDUSTRIES 621.317.8

Electricity for Industry: evidence submitted on 26th October, 1954, to the committee of inquiry into the working of the electricity supply industry, appointed by H.M. Government under the chairmanship of Sir Edwin Herbert

8vo. pp. 11. London: F.B.I., 1954. 1*s.*

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

A.C. Signalling—a Review of Current Problems, by B. R. Horsfield and D. C. Smith. Paper read before the London Centre of the Institution on 8th April, 1952 (No. 204)

4to. pp. 36. London: Institution of Post Office Electrical Engineers, n.d.

Subscriber Trunk Dialling in the United Kingdom: A review of the problems arising and a discussion of their solution, by D. A. Barron. Paper read before the London Centre of the Institution on 11th November, 1952. (No. 203)

4to. pp. 25. London: Institution of Post Office Electrical Engineers, n.d.

INTERNATIONAL CONFERENCE ON LARGE ELECTRIC SYSTEMS (C.I.G.R.É.)

Proceedings of the 15th Convention, May 12–22, 1954, edited by J. Tribot Laspière. Vol. 3, 3rd and 4th sections, papers 301 to 343 and 401 to 411

8vo. Paris: C.I.G.R.É., 1954. £16 6*s.* 6*d.* for 3 vols.

MONOGRAPHS AND PAPERS
published separately this month

Separate Monographs and reprints of all papers published in the Proceedings are available at the price of 1s. 3d. each (post free). The inclusive charge for a copy of a paper allocated for reading at a meeting on separate publication and for a reprint of the paper and discussion (as republished in the Proceedings) is 2s. 6d. (post free). This charge is made whether or not the reprint is required, but a reprint alone costs 1s. 3d., as noted above. However, separate copies of a paper allocated for reading are supplied free of charge 10 days before the first meeting at which the paper is to be read, whether in London or in the provinces. If a reprint also is required, a remittance should accompany the request. Reprints of a paper being read at a meeting cannot be issued before the paper and discussion have appeared in the Proceedings, but they should preferably be ordered before or shortly after the paper has been read in London.

In an order, a Monograph or a paper can be specified completely by the author's surname and the serial number of the paper. Those who wish to avoid making a separate payment for each Monograph, paper, or reprint which they require can obtain books of voucher-labels, price 10s. each, containing 8 vouchers, on application to the Secretary.

A list of papers published in the May issue of Part B of the Proceedings appears under "Contents of the Current Issues of the Proceedings" on page 336, and the serial number of each paper and the month of publication of a digest in the Journal is included. Synopses of both Monographs and papers which have not yet been announced and which have been already published separately, or will be before the next issue of the Journal, appear below, and unless otherwise stated, their date of publication is the same as this issue of the Journal. The Monographs will be republished in Part C of the Proceedings, and the relevant Part for the republication of a paper is given after the serial number of the paper.

MONOGRAPHS

E. UHLMANN, Dr.Ing.

Alternating Voltage, Direct-Voltage Regulation and Power Factor of Convertor Stations operating on A.C. Systems of Finite Short-Circuit Capacity

MONOGRAPH No. 131 S

The paper deals with the effect of the impedance of the a.c. system on the voltage and power factor at the a.c. terminals of a convertor such as a mercury-arc-rectifier group, and on the direct-voltage regulation of this group. For convenience, the results are given as charts of curves, which are also being incorporated in a forthcoming I.E.C. publication, and the paper gives the derivation of these.

For the investigation an equivalent connection diagram is used, the impedance of the a.c. system, including that of the generators feeding the system, being shown on this. A formula is derived relating the r.m.s. value of the alternating voltage, U_L, in the convertor station and that at the imaginary feeding point, where the voltage, even with convertor loading, remains sinusoidal.

The results obtained are used in the deduction of the additional direct-voltage regulation, due to the a.c. system, which must be introduced on the d.c. side if the conventional theory of convertors has been used to calculate the direct voltage; in this the convertor-station voltage has been assumed to be sinusoidal and of r.m.s. value equal to U_L. Curves are given showing the voltage regulation over a range covering most practical cases. A formula for calculating the fundamental wave of the alternating voltage in the convertor station is also derived in the paper. By means of this formula, together with that for the r.m.s. value of the convertor-station alternating voltage, it is shown that the displacement factor and power factor in the convertor station are determined by factors which depend entirely on known plant and a.c.-system data, and consequently that acceptance-test measurements of power factor in convertor stations actually serve no useful purpose, since they merely confirm this fact.

A digest of the Monograph will be published in Part A of the *Proceedings*.

I. A. HARRIS

The Theory and Design of Coaxial Resistor Mounts for the Frequency Band 0–4 000 Mc/s

MONOGRAPH No. 132 R

An account is given of the theoretical basis for the design of coaxial resistors that retain their d.c. resistance, without appreciable reactance, at all frequencies at which coaxial systems are normally used. The main restriction on physical size is governed by the avoidance of supplementary modes of propagation. The design employs a uniform cylindrical film resistor with a critically dimensioned outer conductor, the profile of which has the form of a tractrix. Lead-in cones are designed to avoid discontinuity at the connections with the resistor and the outer conductor. Experimental results show an impedance within 1% of the d.c. resistance, with an extremely small phase angle, at all frequencies up to the highest measured, namely 3 450 Mc/s.

A digest of the Monograph will be published in Part B of the *Proceedings*.

I. THOMAS, B.Sc.

Second-Order Torque Components in the Schrage Motor Operating at Synchronous Speed

MONOGRAPH No. 133 U

The operation of a Schrage motor at synchronous speed is considered, and on the assumption that the air-gap flux at this speed contains space harmonics, an expression for the torque is derived in terms of flux-axis position. This shows the torque to consist of the main component, which is constant for constant brush separation, and variable components depending on (*a*) unbalance in the secondary circuits due to errors in brush separation angles and/or unequal secondary resistances, and (*b*) the assumed space harmonics of flux. The variable torque components give rise to superimposed

speed oscillations and primary current hunting when the average speed is just above or below synchronism.

An experimental method of investigating the torque is given, together with two methods of measuring the harmonic content of the air-gap flux. The latter measurements are used to predict the amount by which the total torque varies with the air-gap flux-axis position at synchronous speed. Possible errors are discussed, and an approximate correction for non-linearity due to the brush contact effect is derived and applied. The experimental results given for a 2-phase machine show reasonable agreement with the theory.

A digest of the Monograph will be published in Part A of the *Proceedings*.

PAPERS

D. L. HOLLWAY

An Electrolytic-Tank Equipment for the Determination of Electron Trajectories, Potential and Gradient

PAPER No. 1837 M; PART B

A description is given of a general-purpose electrolytic-tank equipment of simple design. Provision is made for testing either axially-symmetric or two-dimensional models, and the associated circuits can be arranged by switching (*a*) to measure potentials, (*b*) to mark equipotentials automatically, (*c*) to measure potential gradients and (*d*) to trace electron trajectories. As a test of accuracy a family of parabolic trajectories was compared with calculated paths. The errors were found to be less than 1% of the true co-ordinates, indicating that the accuracy is sufficient for most problems found in the design of electrode structures.

D. L. HOLLWAY

A Method of Tracing Electron Trajectories in Crossed Electric and Magnetic Fields

PAPER No. 1838 M; PART B

It is shown that Gabor's tangent method of electron-path tracing may be extended to problems which include the determination of paths in the presence of crossed electric and magnetic fields. The magnetic field may be either constant or it may vary with position if the distribution is known. The possible extension to time-varying fields is indicated. Experimental results are given, including a trochoid compared with the calculated path and typical paths in a split-anode magnetron.

J. M. WADDELL, M.A., S. E. MAYER, Ph.D., and S. KAYE, B.Sc.

A Germanium Diffused-Junction Photo-Electric Cell

PAPER No. 1860 R; PART B

The paper was published on April 30th

The paper describes a new type of germanium-junction photo-electric cell, in which the junction is manufactured by impurity diffusion. This type of cell differs from those made by other methods in having a lower noise level and a slightly extended long-wave response. The possible causes of this latter anomaly are discussed, and some applications are suggested which utilize both effects.

Two practical photocells are described which differ mainly in physical dimensions. Both are hermetically sealed and have high sensitivity and large output for their size. It is shown that the maximum reverse voltage that can be applied to a germanium junction device is a function of the cooling arrangements provided. The special case of the photocell is considered, and it is shown that the criterion for thermal stability is temperature rise rather than absolute temperature. For a germanium photocell in the dark the maximum temperature rise is approximately 11° C.

R. A. HILBOURNE, B.Sc., and D. D. JONES, M.Sc.

Transistor Power Amplifiers

PAPER No. 1861 R; PART B

The paper was published on April 30th

The factors governing the power-handling capabilities of *p–n–p* junction transistors in sinusoidal amplifiers are discussed. It is shown that, although the maximum allowed collector dissipation is an important transistor design criterion, it does not necessarily indicate the limit to the maximum output power possible; limitations set by other factors, notably the variation of current gain with emitter current, become particularly significant in Class B amplifiers because of their very high efficiencies. The relative importance of Class A and Class B amplifiers is considered, and the three possible Class B push-pull arrangements are analysed in detail. It is shown that load-line techniques, such as are used in designing thermionic-valve power-amplifiers, are not really suitable for transistors, and a different approach is made.

It is concluded that the common-collector Class B push-pull amplifier has a number of attractive features which favour its use. The design of a driver stage for this amplifier is described.

L. H. LIGHT, B.Sc., and P. M. HOOKER, B.Sc.

Transistor D.C. Convertors

PAPER No. 1862 R; PART B

The paper was published on April 30th

A transistor relaxation-oscillator circuit serving as a direct-voltage step-up device is described. The transistor acts as an interrupter in a low-voltage circuit; energy is stored during the "on" period in the transformer inductance and is delivered to the output circuit at an increased voltage during the "off" period.

The paper contains a full account of the operating principles and design of the circuit for efficient power conversion, a brief analysis of voltage-doubler variants and a discussion of the performance and applications of practical d.c. convertors. It also presents some methods of dealing with problems associated with the circuit, such as stabilization of output voltage and fault protection.

Transistor convertors have several advantages over competitive methods at power levels from a fraction of a milliwatt up to several watts, such as high efficiency, long life and small size. They therefore promise to become the preferred method of generating h.t. voltages from l.t. supplies at low power levels, except when temperature conditions are unsuitable for the semi-conductor elements employed.

SOME RECENT BOOKS

V. C. RIDEOUT
ACTIVE NETWORKS
CONSTABLE. 501 PP. £2 2s.

The author, who is Assistant Professor of Electrical Engineering at the University of Wisconsin, claims in his preface that "this book is intended primarily for the reader who has studied the physics of vacuum tubes and related devices, as well as the theory of passive linear networks." He also indicates that much of the material in the text has been used in a mimeographed form in a course for senior electrical engineering students.

These facts provide a clue to some of the ways in which British readers may find this a difficult book to read. To those who received their basic training in the lower schools of American universities, the nomenclature, terminology, method of attack of problems and style will be not unfamiliar. To those who have some experience of lecturing and who are able to extrapolate, from between the lines, shades of meaning not conveyed in cold words, the book will be stimulating. Those who are neither American trained nor well versed in the art of lecturing from notes, will, however, experience difficulty arising from unfamiliar nomenclature and a tendency towards over-abbreviation in explanation.

As a random example of the latter one finds on page 289 the surprising fact that "no signal containing information is a single-frequency sinusoid for long"; again on the previous page, the author states that time-division-multiplex "may be used to send hundreds of telephone signals simultaneously over microwave relay systems with but a single s-h-f carrier frequency." Examples of terminology causing minor irritation are the use of "FM" as a synonym for "v.h.f." (this, too, in a chapter on modulation), the use of "phasor" throughout for "vector" and the omission of "/sec" in all references to frequency. Surprisingly enough, however, the bibliographical references contain a reasonable number of allusions to British practice, though one wonders how many British readers will appreciate the abbreviated references to "Proc N.E.C.," which research by the present reviewer has shown to be used for the "Proceedings of the National Electronic Conference."

Trivialities, maybe, but in unguarded and torpid minds these difficulties may be deceptive and dangerous. With this qualification, however, the book can be thoroughly recommended. Its mathematical treatments (especially that of the Laplace transformation in Appendix B) are unusually clearly laid out, and it brings within the compass of a single volume a variety of subjects (such as signal-to-noise ratio, information theory and transistors) not hitherto available in this form. One wonders, however, whether there is particular significance behind the rather curious choice of the symbol £ for insertion loss.

There is a marked difference in the quality of production between the original American and the British editions of the book. The British edition, which is reviewed here, appears to have been indifferently printed by photo-lithography from the American printed sheets, and the definition is so poor in places that the text and illustrations become uncomfortable to the eyes. A worth-while compensation, however, is the fact that the British edition is some 35s. cheaper than its American counterpart.

K. H. STEWART
FERROMAGNETIC DOMAINS
CAMBRIDGE UNIVERSITY PRESS. 186 PP. 25s.

This book is one of a series whose aim is to present the results of recent research in pure physics, and it gives a review of theoretical and experimental work on domains in ferromagnetic metals. Its appearance is opportune, for progress in this subject has been rapid in the past 10 years, following Néel's notable theoretical contributions and the subsequent confirmatory experimental work of Bozorth and his colleagues.

There are eight chapters in all, dealing first in a general way with domains and then with magneto-crystalline anisotropy, magnetostriction, domain geometry, domain boundary walls, the possible mechanisms which may impede domain boundary movement, with time effects in crystals and with magneto-thermal phenomena. The author's own stimulating work on time effects in silicon-iron is discussed, not unnaturally perhaps, in disproportionate detail.

The author has included all the main theories relating to permeability and coercive force, although some of them, such as Kersten's foreign-body theory and some of Néel's work, have been found, since they were first published, to be unsound in their premises or to suffer from mathematical defects—e.g. equation (6.6) in the book was later said by its author to be wrong. There are, however, fruitful ideas in these theories which should be known, but more emphasis in the book on their shortcomings or failures would be helpful to the inquiring student. On the other hand, the work of Stoner and Wohlfarth on coercivity and hysteresis, which is simple in conception, completely free from mathematical obscurities and satisfactorily accounts for any value of coercivity yet observed, might have been more fully treated.

In Section 5.6 domain-boundary energy has been estimated, using the superseded classical Langevin–Weiss theory. The established quantum-mechanical modification of this is more in accord with the experimental evidence and makes a difference of three times in the energy calculation. Fig. 31(*b*) of the book is in error; the picture of domains given there is not the ideal equilibrium condition. A state of lower energy is achieved by removing the central domain boundary and then reversing the arrows on one side of it.

However, in spite of these minor criticisms, the book should be a useful one to students and research workers interested in this subject. It can be confidently recommended to them provided that they read it critically.

C. R. URWIN (*General Editor*)
IBBETSON'S ELECTRIC WIRING
E. AND F. N. SPON. 9TH EDITION. 304 PP. 11s. 6D.

This book should undoubtedly appeal to those who are

studying for electrical installation examinations such as those of the City and Guilds Institute, for it covers much of the necessary subject-matter. First published in 1909, it is now in its ninth edition and has been skilfully brought up to date by the revision of much of the text and by the inclusion of new material on recent techniques.

While intended primarily for the student, it should also be useful, to some extent, to the qualified technician or engineer, as a reference book, or for teaching purposes. In addition to setting out basic theory, everyday problems and details of modern practice, it is well illustrated with diagrams and photographs and includes many examples of installation problems, the solutions of which are worked out in detail.

The first four chapters are devoted to the theory which is essential to a study of electrical installation and wiring work, and these form an indispensable prelude to the proper understanding of the practical aspects covered in the succeeding 11 chapters. Chapter 5 is on instruments, and is followed by one on insulating materials and cables, while Chapters 7 and 8 are devoted to distribution and wiring systems, and Chapter 9 to a brief survey on general utilization. Simple communication systems is the subject of the next chapter and the reader is then given a useful insight into the problems associated with the testing of installations and fault-finding. Chapter 12 considers illumination, and the three final chapters are concerned with primary and secondary cells, small generating plant, and motors. The book also contains some mathematical tables.

Each chapter gives a comprehensive survey of its subject, but a small criticism is the slight lack of sequence, which seems to be almost inevitable in a work that has been brought up to date a number of times. In addition, although the book has been revised most capably by the three editors, Mr. C. R. Urwin, Mr. W. F. Parker and Mr. F. G. Thompson, each of whom has an intimate knowledge of the subject, their differing literary styles show up clearly in the text.

The book is well produced and is written with an essentially practical approach; it should prove a valuable addition to the library of anyone whose interests lie in electrical wiring and installation work.

V. K. ZWORYKIN and G. A. MORTON
TELEVISION

NEW YORK: JOHN WILEY.
LONDON: CHAPMAN AND HALL.
2ND EDITION. 1052 PP. £7.

In common with the first edition published 14 years ago, the second edition of this book presents a very comprehensive survey of the whole field of television engineering, with emphasis on contemporary American techniques. The many developments which have taken place since the first edition was written have demanded considerable revision of most of the book and the addition of much new material. In particular, three new chapters have been included to deal with the subject of colour television.

In terms of American practice it is indeed difficult to find a single aspect of television which has been neglected, although the treatment in places is necessarily very abridged. Whether it would have been better to have dealt, for example, less with transmitter design and more with video-frequency transmission, is a matter of opinion. There is no doubt, however, that the authors have achieved a substantial measure of success in their endeavour to cover the entire field in a single volume.

The subject-matter is divided into four main parts, the first of which is concerned with fundamental physical principles, and is particularly noteworthy for two new sections dealing with the behaviour of semi-conductors and photo-conductors, respectively. An up-to-date survey of the properties of fluorescent materials is included, and there are two well-presented chapters on electron optics. The whole of this part is most informative and should be valuable to the student or engineer seeking basic knowledge of the subject.

Part 2 serves as a useful introduction to the principles involved in practical systems of television. Picture resolution, the theory of scanning, video transmission and reception, pick-up and reproducing devices, are all discussed, although largely in terms of current American practice. A notable addition is a short description of the Eidophor light valve and its application to large-screen television. A section comprising a rather involved mathematical treatment of single-sideband transmission and reception appears somewhat out of place. Vector diagrams would have served better to illustrate the relatively simple conclusion.

Much of the book is devoted to Part 3, which deals comprehensively with the design and performance of component elements of a television system. The opening chapter is concerned solely with the iconoscope, and is followed by a chapter on the more recent developments in camera-tube design, leading to the image orthicon and photo-conductive tube. Two subsequent chapters deal with picture-display tubes (kinescopes) and the design of the electron gun in its application to both camera tubes and display tubes. The detailed information in these four chapters is particularly well presented.

The remaining four chapters of Part 3 cover video amplification, scanning and synchronization, the television transmitter, and the television receiver. In considering video amplification the authors could have said more about group-delay distortion and phase correction. The method of introducing the Laplace transform in Section 13.11 as a means of determining the response of a video amplifier is confusing and would have been better omitted; since the Fourier integral is used freely throughout the book, it would have been more useful simply to identify the Laplace transform with the complex form of the Fourier integral, and to include a reference to published tables of transforms.

Part 4 comprises three chapters on colour television, a short chapter on industrial application of television, and a concluding chapter on current American television broadcasting practice.

The chapters on colour television are particularly noteworthy since they serve not only as a useful introduction to this subject, but also bring the reader right up to date by discussing the significant developments that led to the National Television System Committee colour-signal specification which was officially adopted by the Federal Communications Commission at the end of 1953. Colour vision and colorimetry are dealt with in sufficient detail to enable the intelligent reader to understand the subtleties of the recent developments. There is also much useful and up-to-date information on colour circuits, colour cameras, and picture tubes, with particular emphasis on the shadow-mask tube.

The final chapter contains some interesting facts concerning American television practice, including the layout of modern studios and transmitters, coaxial- and microwave-relay routes,

details of telerecording, and even brief mention of video recording on magnetic tape.

The book as a whole is well written and well illustrated. To facilitate further study an adequate list of references has been appended to each chapter, and a complete author index is included at the end of the book. The fact that much of the subject-matter is concerned with American practice will not prevent the book from being of considerable value to any student or engineer wishing to acquire up-to-date knowledge of this vast subject.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH APRIL, 1955

	No. of Contributors	£	s.	d.
£1 000 and over	6	6000	0	0
£100 to <£1 000	29	6386	3	0
£5 to <£100	736	8231	1	10
£2 to <£5	1796	5016	19	7
Under £2	17246	9175	14	5
		£34809	18	10

APPOINTMENTS AND NOMINATIONS

BRITISH STANDARDS INSTITUTION TECHNICAL COMMITTEES:

Instruments for Aircraft Apparatus (*ACE/30*)

The Council have nominated Mr. V. A. Higgs, B.Sc., Associate Member, to serve on the above Committee in place of Mr. C. G. A. Woodford, Member.

Consumer Supply Control Units (*ELE/57*)

Meter Space (*B/65*)

Sub-Committee on Electrical Meter Space (*B/65/1*)

The Council have nominated Mr. H. C. Spence, Member, to serve as their representative on the above Committees in place of Mr. J. W. J. Townley, C.B.E., Member.

Overhead Transmission Lines Material (*ELE/17*)

The Council have nominated Mr. H. W. Grimmitt, Member, to serve as their representative on the above Committee.

Insulators for Power Systems (*ELE/70*)

The Council have nominated Mr. P. K. Davis, Member, to serve as their representative on the above Committee.

CODES OF PRACTICE COUNCIL: CODE DRAFTING COMMITTEE FOR THE PREPARATION OF A CODE ON DAYLIGHT, SUNLIGHT AND ARTIFICIAL LIGHT

The Council have nominated Mr. W. R. Stevens, B.Sc., Member, to serve as their representative on the above Committee.

CODES OF PRACTICE COUNCIL: CODE DRAFTING COMMITTEE ON SUPPLY, METERING AND CONSUMERS' CONTROLS

The Council have nominated Mr. H. C. Spence, Member, to serve as their representative in place of Mr. J. W. J. Townley, C.B.E., Member.

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

On the nomination of the Ministry of Transport and Civil Aviation, the Council have appointed Mr. F. J. Welch to serve on the above Committee in place of Mr. F. J. Colvill.

COMMITTEE ON RADIO INTERFERENCE

The Council have appointed Mr. T. E. Goldup, C.B.E., Vice-President, to serve on the above Committee in a personal capacity.

NATIONAL INSPECTION COUNCIL FOR ELECTRICAL INSTALLATION CONTRACTING

The Council have nominated Mr. P. V. Hunter, C.B.E., Honorary Member, and Mr. Forbes Jackson, Member, to serve as their representatives on the National Inspection Board which will carry out the executive functions of the above Council.

THE INSTITUTION EXAMINATION

EXEMPTION THROUGH NATIONAL CERTIFICATE COURSES

It has been decided to increase by one year the period in which candidates may satisfy The Institution's educational requirements through the National Certificate scheme under the old Regulations, which are being superseded by those published in September, 1953.

Candidates must accordingly gain exemption from all the subjects of the Institution Examination under the old Regulations, except English, not later than the end of the academic year 1956–57.

CORRESPONDENCE

In view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members, in replying to letters received from the Secretary, quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches, without delay, the department concerned, but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

Members are reminded that notifications of changes of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one Local Centre or Sub-Centre to another arises as a result of a change of

address, this transfer is automatically arranged by headquarters and there is no need for the member concerned to notify also the Hon. Secretary of the Local Centre or Sub-Centre.

To obviate the possibility of errors in the records, members are particularly requested, when notifying a change of address, to give their full initials, their previous address and their class of membership.

THE INSTITUTION STAFF: EDITORIAL VACANCY

There is a vacancy for an editorial assistant for work on the *Journal* of The Institution. Applicants for this post must possess an engineering or a science degree and some engineering experience. Journalistic knowledge is desirable, but those without it who have literary ability and a desire to take up technical journalism will be favourably considered. The post offers good prospects for advancement. Applicants should be between the ages of 25 and 30 (approximately). The salary will depend on age, qualifications and experience. Entry to a superannuation scheme would follow a short period of service.

Those who are interested should write to the Secretary, Savoy Place, London, W.C.2, giving full particulars of their education, training and experience.

THE NEW ZEALAND INSTITUTION OF ENGINEERS

Members who subscribe to *New Zealand Engineering* (the Journal of the New Zealand Institution of Engineers) are requested to note that the privilege rate of subscription to this publication has been raised from 10s. 6d. to 14s. 6d.

TECHNICAL STATE SCHOLARSHIPS

In future, Technical State Scholarships will be awarded by the Ministry of Education to students from technical colleges and establishments for further education. The majority of the scholarships will be offered to students who have obtained an Ordinary National Certificate or corresponding qualification and wish to pursue a course of full-time study in preparation for an honours degree or equivalent qualification. Most of the awards will be allocated to applicants under 21 years old on the 31st July, 1955, although allowance will be made for any period spent in National Service. Some scholarships will, however, be available to candidates who are over 21.

A limited number of awards may also be made to candidates who have obtained an initial qualification of the standard of a university first degree or Higher National Certificate to attend approved post-graduate courses of study or research in applied science or technology.

Further particulars and entry forms may be obtained from the Secretary, Ministry of Education, F.E., 1(d) Curzon Street, London, W.1, or from the principal of an establishment of further education. Application forms must reach the Ministry of Education by the 30th June, 1955.

SUMMER SCHOOL ON COMPUTERS

A four-week course on digital and analogue computers and their application to electrical engineering problems will be given at Imperial College, London, from the 31st May, to the 24th June, 1955. The course is intended to acquaint electrical engineers with the computing facilities that are now becoming available, to introduce them to the methods used for the solution of typical engineering problems and to instruct them in the presentation of problems for computation.

The course is being given by the Department of Electrical Engineering, with the help of the Mathematics Department, of Imperial College, by members of the staff at the National Physical Laboratory and by various firms and organizations engaged in computer manufacture and application.

Further particulars can be obtained from the Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7. The number attending the course will be restricted to about 20.

CONFERENCE ON THE PHYSICS OF NUCLEAR REACTORS

The Institute of Physics is arranging in London from the 3rd to 6th July, 1956, a Conference on the Physics of Nuclear Reactors, which the President of the Institute, Sir John Cockcroft, K.C.B., C.B.E., M.A., D.Sc., M.Sc.Tech., Ph.D., will open with an Address on "The Scientific Problems in the Generation of Nuclear Power." The primary purpose of the Conference is to keep members of the Institute, particularly those engaged in industry, informed about recent development in reactor physics and the cognate scientific and technical subjects, but a limited number of non-members will be able to attend by invitation. Further details will be announced in the autumn of this year.

RESIDENTIAL COURSE OF PRACTICAL WORKSHOP TRAINING

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

To meet the needs for practical workshop training of oversea students who are unable to obtain this in British industrial firms a Summer Vacation Course has been arranged at Loughborough College of Technology from the 8th August to the 17th September, 1955. Instruction will be given in the following workshops: foundry; general engineering shop; general machine shop; heavy lathe shop; grinding shop; automatic shop; pattern shop; milling machine shop; electrical fitting and winding shop; generating station; and drawing offices. Evening lectures on workshop and manufacturing subjects may be arranged.

The college workshops operate as a production factory, and students will be instructed under production conditions. Programmes of work will be planned for each student so far as possible to fit his previous experience and requirements. The main object will be to make each student acquainted with the uses and limitations of various hand and machine tools in conjunction with different materials, and with workshop and manufacturing processes.

Residence will be provided in one of the Halls of Residence, and lunches will be available in the central dining hall. There will be opportunities for swimming, squash rackets and lawn tennis.

The fee for the course is £25 exclusive of board and accommodation. Further particulars and application forms for those wishing to attend the course may be obtained from the Registrar, The College of Technology, Loughborough, Leicestershire, England. Completed forms must be sent in before the 1st July, 1955.

THE JOURNAL REFERENCE SECTION *(pages 334-336)*

PATRON OF THE INSTITUTION: H.M. THE QUEEN

Council, 1954–55

PRESIDENT
J. ECCLES, C.B.E., B.SC.

PAST-PRESIDENTS
SIR JAMES SWINBURNE, BART., F.R.S.
W. H. ECCLES, D.SC., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGCUMBE, T.D.
J. M. DONALDSON, M.C.
PROFESSOR E. W. MARCHANT, D.SC.
P. V. HUNTER, C.B.E.
H. T. YOUNG
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.ENG., LL.D.
J. R. BEARD, C.B.E., M.SC.
SIR NOEL ASHBRIDGE, B.SC.(ENG.)
COLONEL SIR A. STANLEY ANGWIN, K.B.E., D.S.O., M.C., T.D., D.SC.(ENG.)
SIR HARRY RAILING, D.ENG.
P. DUNSHEATH, C.B.E., M.A., D.SC.(ENG.)
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROFESSOR E. B. MOULLIN, M.A., SC.D.
SIR ARCHIBALD J. GILL, B.SC.(ENG.)
SIR JOHN HACKING
COLONEL B. H. LEESON, C.B.E., T.D.
H. BISHOP, C.B.E., B.SC.(ENG.)

VICE-PRESIDENTS
T. E. GOLDUP, C.B.E.
S. E. GOODALL, M.SC.(ENG.)
WILLIS JACKSON, D.SC., D.PHIL., F.R.S.
SIR GEORGE H. NELSON
SIR W. GORDON RADLEY, C.B.E., PH.D.(ENG.)

HONORARY TREASURER
H. W. GRIMMITT.

Ordinary Members of Council
J. BENNETT
A. R. COOPER
A. T. CRAWFORD, B.SC.
C. DANNATT, O.B.E., D.SC.
B. DONKIN, B.A.
O. W. HUMPHREYS, B.SC.
C. R. KING, C.B.E.
H. R. L. LAMONT, PH.D., M.A., B.SC.
F. J. LANE, O.B.E., M.SC.
G. S. C. LUCAS, O.B.E.
G. LYON, M.SC.(ENG.)
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC.
A. H. MUMFORD, O.B.E. B.SC.(ENG.)
W. F. PARKER
PROFESSOR M. G. SAY, PH.D., M.SC.
R. L. SMITH-ROSE, C.B.E., D.SC., PH.D.
G. O. WATSON
J. H. WESTCOTT, B.SC.(ENG.), PH.D.
E. L. E. WHEATCROFT, M.A.
R. T. B. WYNN, C.B.E., M.A.

Chairmen and Past-Chairmen of Sections

Measurements
M. WHITEHEAD.
•J. F. COALES, O.B.E., M.A.

Radio
C. W. OATLEY, M.A., M.SC.
•J. A. SMALE, C.B.E., A.F.C., B.SC.

Chairmen and Past-Chairmen of Sections —*contd.*

Supply
J. D. PEATTIE, B.SC.
•L. G. BRAZIER, PH.D., B.SC.

Utilization
J. I. BERNARD, B.SC.TECH.
•B. L. METCALF, B.SC.(ENG.)

Chairmen and Past-Chairmen of Local Centres

East Midland Centre
J. H. MITCHELL, B.SC., PH.D.
•C. D. WILKINSON

Mersey and North Wales Centre
P. R. DUNN, B.SC.
•T. COATES, M.ENG.

North Midland Centre
W. A. CROCKER
•G. CATON

North-Eastern Centre
G. W. B. MITCHELL, B.A.
•H. ESTHER, B.ENG.

North-Western Centre
PROFESSOR E. BRADSHAW, M.B.E., M.SC.TECH., PH.D.
•H. WEST

Northern Ireland Centre
MAJOR P. L. BARKER, B.SC.
•J. R. W. MURLAND, B.SC.(ENG.)

Scottish Centre
J. S. HASTIE, B.SC.(ENG.)
•C. H. A. COLLYNS

South Midland Centre
A. R. BLANDFORD
•H. J. GIBSON, B.SC.

Southern Centre
E. A. LOGAN, M.SC.
•CMDR. C. V. ROBINSON, R.N., O.B.E.

Western Centre
A. N. IRENS
•J. VAUGHAN HARRIES

• *Past-Chairman.*

SECRETARY W. K. BRASHER, C.B.E., M.A., M.I.E.E.

Deputy Secretary F. JERVIS SMITH, M.I.E.E.

Assistant Secretary F. C. HARRIS

Editor-in-Chief G. E. WILLIAMS, B.SC.(ENG.), M.I.E.E.

***Journal* Editor** C. T. RIVINGTON, M.A., A.M.I.E.E.

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	S	SUPPLY SECTION
M	MEASUREMENTS SECTION	U	UTILIZATION SECTION
R	RADIO SECTION		

After each paper that has now been published is added the month that its synopsis appeared in the *Journal*.

1955

MAY

17 *Tuesday*	Questions Night* (At 6 p.m., tea 5.30 p.m.)	E
18 *Wednesday*	D. B. IRVING, B.SC. "The Supply of Electricity in the London Area" (Paper No. 1748)‖ *Synopsis:* November, 1954	S
19 *Thursday*	Annual General Meeting *followed by* THE RT. HON. LORD CITRINE, P.C., K.B.E. Lecture on "Human Relations in Industry"* (At approximately 6.30 p.m.)	

JUNE

6 *Monday to* 11 *Saturday*	Summer Meeting in the North of Scotland	
17 *Friday*	Measurements Section Summer Visit to Electric and Musical Industries, Hayes; Wisley Gardens; and the Central Electricity Authority's Training Establishment, Horsley Towers, East Horsley	M
25 *Saturday*	Radio Section Summer Visit to Rugby	R

SEPTEMBER

8 *Thursday to* 12 *Monday*	Supply Section Summer Visit to Holland	S

* No advance information will be available.

‖ This paper has now been published.

Contents of the current issues of the Proceedings

DATE OF JOURNAL DIGEST OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (APRIL 1955)

Digest not yet published
J. B. YOUNG, B.SC., AND D. H. TOMPSETT, B.SC.(ENG.)
Short-Circuit Forces on Turbo-Alternator End-Windings (PAPER NO. 1683 S, JULY 1954)

Digest not yet published
D. ANTRICH, B.SC.(ENG.), H. W. B. GARDINER, B.SC.(ENG.), AND R. K. HILTON, B.SC.(ENG.)
Supervisory Equipment for the Indication of Shaft Distortion in Steam Turbines (PAPER NO. 1622 S, APRIL 1954)

Digest not yet published
J. L. ASHWORTH, J. S. HALL, B.SC.TECH., AND A. H. GRAY, M.SC.
The Electrical Measurement of Steam-Turbine Rotor Movements, with special reference to the Operation and Design of Modern Power Plant (PAPER NO. 1680 S, SEPTEMBER 1954)

Written discussion on **Electricity in Medicine**

Mersey and North Wales Centre: Chairman's Address

April 1955
J. A. BROUGHALL, B.SC.(ENG.), AND K. J. COOK, O.B.E.
The Electrification of the Manchester–Sheffield–Wath Lines, Eastern and London Midland Regions, British Railways (PAPER NO. 1744, OCTOBER 1954)

January 1955
J. G. BRUCE, B.SC.
The Overhaul and Maintenance of Direct-Current Traction Motors (PAPER NO. 1723, NOVEMBER 1954)

Discussion on **The Uses of Earthed Signal Conductors on Transmission Circuits** before the North Midland Centre

February 1955
PROFESSOR F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., AND E. R. LAITHWAITE, M.SC.
A Brushless Variable-Speed Induction Motor (PAPER NO. 1737 U, NOVEMBER 1954)

Written discussion on **Transient Behaviour of Ladder Networks of the Type representing Transformer and Machine Windings**

Discussion on **Fluorescent Discharge-Tube Circuits and Operating Problems** before the North-Western Utilization Group, the Northern Ireland Centre and the North Midland Utilization Group

Contents of the current issues of the Proceedings *(contd.)*

DATE OF JOURNAL DIGEST OR SPECIAL ARTICLE

PART A. POWER ENGINEERING (APRIL 1955) (*contd.*)

Digest not yet published — C. J. BEAVIS
The Use of Electricity in the Production of Calcium Carbide (PAPER No. 1721 U, OCTOBER 1954)

Discussion on **Voltage Transformers and Current Transformers associated with Switchgear** before the South-East Scotland Sub-Centre and the North Midland Centre

Discussion on **Post-Graduate Activities in Electrical Engineering** before the North Midland Centre, the South Midland Centre, the Southern Centre and the North-Eastern Centre

Discussion on **Domestic Electrical Installations—Some Safety Aspects** before the Southern Centre, the North-Eastern Centre, the East Midland Centre, the South Midland Centre, the North-Western Centre, the South-Western Sub-Centre, the North Midland Utilization Group, the South-East Scotland Sub-Centre, the Mersey and North Wales Centre, the Western Centre, Tees-Side Sub-Centre, the Sheffield Sub-Centre and the North Staffordshire Sub-Centre

Discussion on **Insulation of Rotating Electrical Machinery** before the South-East Scotland Sub-Centre

Discussion on **The Co-ordination of Insulation of High-Voltage Electrical Installations** before the South Midland Centre, the Irish Branch, the North Staffordshire Sub-Centre, the North-Western Centre, the North-Eastern Centre and the Mersey and North Wales Centre

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1955)

March 1955 — M. E. HAINE, M.SC., F.INST.P., AND M. W. JERVIS, M.SC.TECH.
The Use of an Electron Velocity Analyser to Stabilize a 50 kV Direct-Voltage Source to a Few Parts in a Million (PAPER No. 1729 M, OCTOBER 1954)

March 1955 — M. W. JERVIS, M.SC.TECH.
A Precision Direct-Current Stabilizer (PAPER No. 1730 M, OCTOBER 1954)

February 1955 — H. PAGE, M.SC., AND G. D. MONTEATH, B.SC.
The Vertical Radiation Patterns of Medium-Wave Broadcasting Aerials (PAPER No. 1714 R, SEPTEMBER 1954)

Discussion on **A Short Modern Review of Fundamental Electromagnetic Theory** before the North-Western Centre

March 1955 — G. W. BOWDLER, M.SC.
An Attracted-Disc Absolute Voltmeter (PAPER No. 1675 M, JULY 1954)

Written discussion on **Experimental Equipment and Techniques for a Study of Millimetre-Wave Propagation**

Discussion on **An Investigation of the Characteristics of Cylindrical Surface Waves** and **Surface Waves** before the North-Eastern Radio and Measurements Group

Digest not yet published — PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.), AND A. E. KARBOWIAK, PH.D.
An Experimental Investigation of Axial Cylindrical Surface Waves supported by Capacitive Surfaces (PAPER No. 1786 R)

March 1955 — H. MCG. ROSS, M.A.
Equipment of Instrumental Accuracy for Recording and Reproduction of Electrical Signals, using Cinematographic Film (PAPER No. 1696 M, AUGUST 1954)

Digest not yet published — E. G. ROWE, M.SC., P. WELCH AND W. W. WRIGHT, B.SC.
Thermionic Valves of Improved Quality for Government and Industrial Purposes (PAPER No. 1740 R, DECEMBER 1954)

Digest not yet published — W. W. H. CLARKE, PH.D., B.SC., AND R. F. NIKKEL, M.A.SC., B.A.SC.
Mean Frequency Determination of Narrow-Band Noise Spectra (PAPER No. 1836 M)

Digest not yet published — R. F. SAXE, PH.D.
Automatic Control and Display in Impulse Testing (PAPER No. 1839 M)

Digest not yet published — R. F. B. SPEED, B.A.
A 24-Channel Pulse-Time Modulation System (PAPER No. 1812 R)

Digest not yet published — G. D. MONTEATH, B.SC.
Coupled Transmission Lines as Symmetrical Directional Couplers (PAPER No. 1833 R)

Digests of Institution Monographs:

D. B. BRICK, PH.D., S.M., A.B.
The Radiation of a Hertzian Dipole over a Coated Conductor (MONOGRAPH No. 113 R, DECEMBER 1954)

T. W. STRAKER, M.SC., PH.D.
The Ionospheric Propagation of Radio Waves of Frequency 16 kc/s over Short Distances (MONOGRAPH No. 114 R, JANUARY 1955)

F. HORNER, M.SC.
A Table of a Function used in Radio-Propagation Theory (MONOGRAPH No. 115 R, JANUARY 1955)

PART C. MONOGRAPHS (MARCH 1955)

See March *Journal*, page 208.